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Technical Report, Jul. 1978 - Feb. 1979
(Cornell Univ., Ithaca, N. Y.) 50 p
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CORNELL UNIVERSITY

Center for Radiophysics and Space Research

ITHACA, N. Y.

CRSR 716

Ge:Ga Testing at Cornell

July 1978 to February 1979

by

D. A. Briotta Jr.

and

J. R. Houck

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INTRODUCTION

This report summarizes the Ge:Ga detector testing at Cornell University over the period from July 1978 to February 1979. The principle aim has been to catalog the spiking and memory behaviors of a number of detectors. The detectors were manufactured at a number of locations using several different contacting techniques. Two detectors manufactured for the IRAS program by Rockwell International were studied more extensively than the others. These detectors IRD 1981 and IRD 1982 were "witness sample" detectors for the IRAS bands 4 ($\sim 80\text{--}120\ \mu$) and 3 ($\sim 40\text{--}80\ \mu$) respectively.

During the testing period both our apparatus and the test procedures have been changed numerous times. At each change we made consistency checks and believe the data are internally consistent from end to end. However, many of the tests added recently (eg the linearity checks) have not been made on the earlier detectors. If desired these tests could be run.

In the next few pages we outline the optical and electronic systems. A table listing the detectors tested is included. A photo album is then presented followed by responsivity, linearity, and noise and signal to noise graphs.

This research was sponsored by JPL Contract 954603.

<u>Detector</u>	<u>Mat'l.</u>	<u>T(cm)</u>	<u>Cavity</u>	<u>Contacts</u>	<u>Tested</u>
Berkeley #1 [†]		0.10	Berk	I ²	29 July, 4 Aug
Berkeley #2 ^{††}		0.10	"	I ²	
IRD #					
1679	E.P.	0.10	CU	Plated	2 Aug(No cavity) 15 Aug, 11 Sept(cavity)
1680	E.P.	0.10	CU	"	5 Sept
1682	R #3	0.15		"	
1683	"	0.15	CU	"	10 Aug, 31 July
1760	R #4	0.10	CU	I ²	13 Sept
1813*	HOB	0.10	CU	Plated	7 Sept
1814	"	"		Plated	
1817*	"	"	SC004	I ²	14 Sept
1818	"	"	SC005	"	
1836	"	"		"	
1837	"	"		"	
1838	"	"	SC011	"	
1839	"	"		"	15 Sept, 19 Sept
1981	R #3	0.11	SC016	"	6 Dec, 16, 25, 29, Jan
1982	"	0.10	SC017	"	21 Dec, 30 Jan
Berkeley			Rock Cavity		16 Nov
Berkeley			Rock Post		
Berkeley			Rock Post		
GGB #3		0.2	CU	I ²	7 Feb

* Sent to M. Hauser

† Sent to F. J. Low

†† Returned to Berkeley

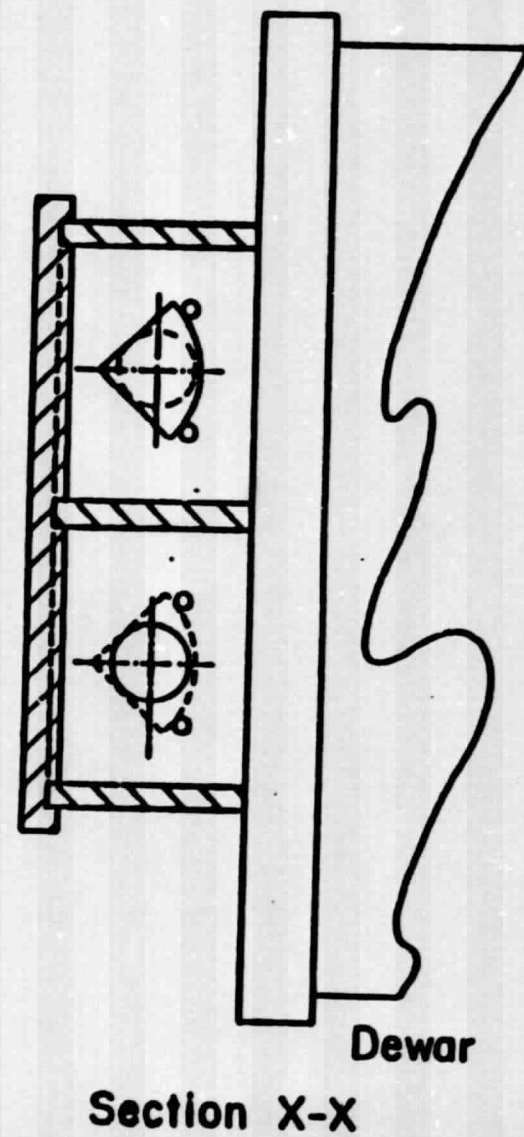
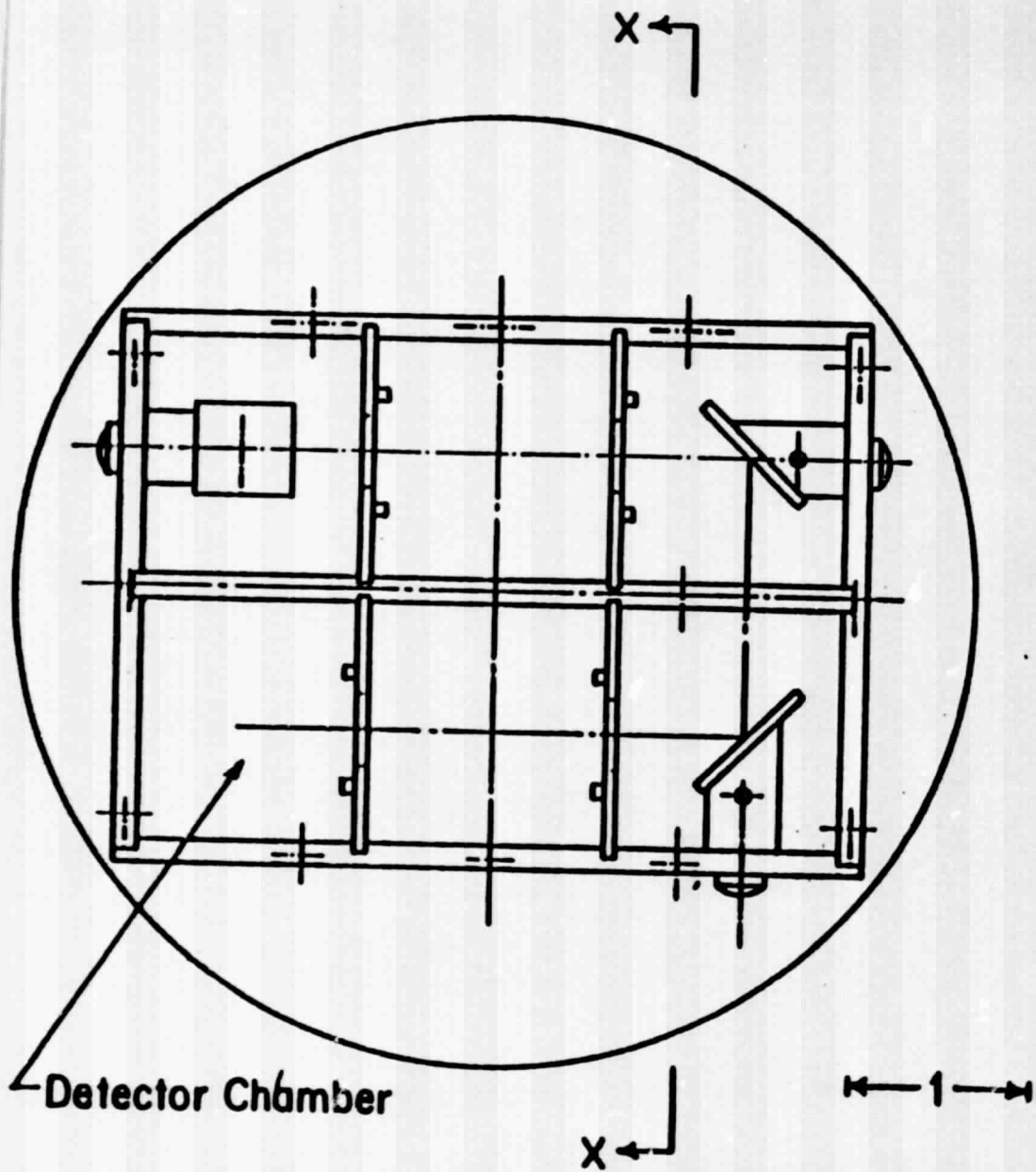
DETECTORS AT CORNELL

During the test program three different optical path configurations were used. These are called OP I, II, III

	FILTERS	WINDOW
OP I	Black Poly, Sapphire, ND (2%)	Poly or Si
OP II	CaF ₂ Quartz (both AR with diamonds, ND (2%))	Si
OP III	As in OPII with night light (note: power levels for the slide were reduced by a factor of 3.1, the ND was moved)	Si

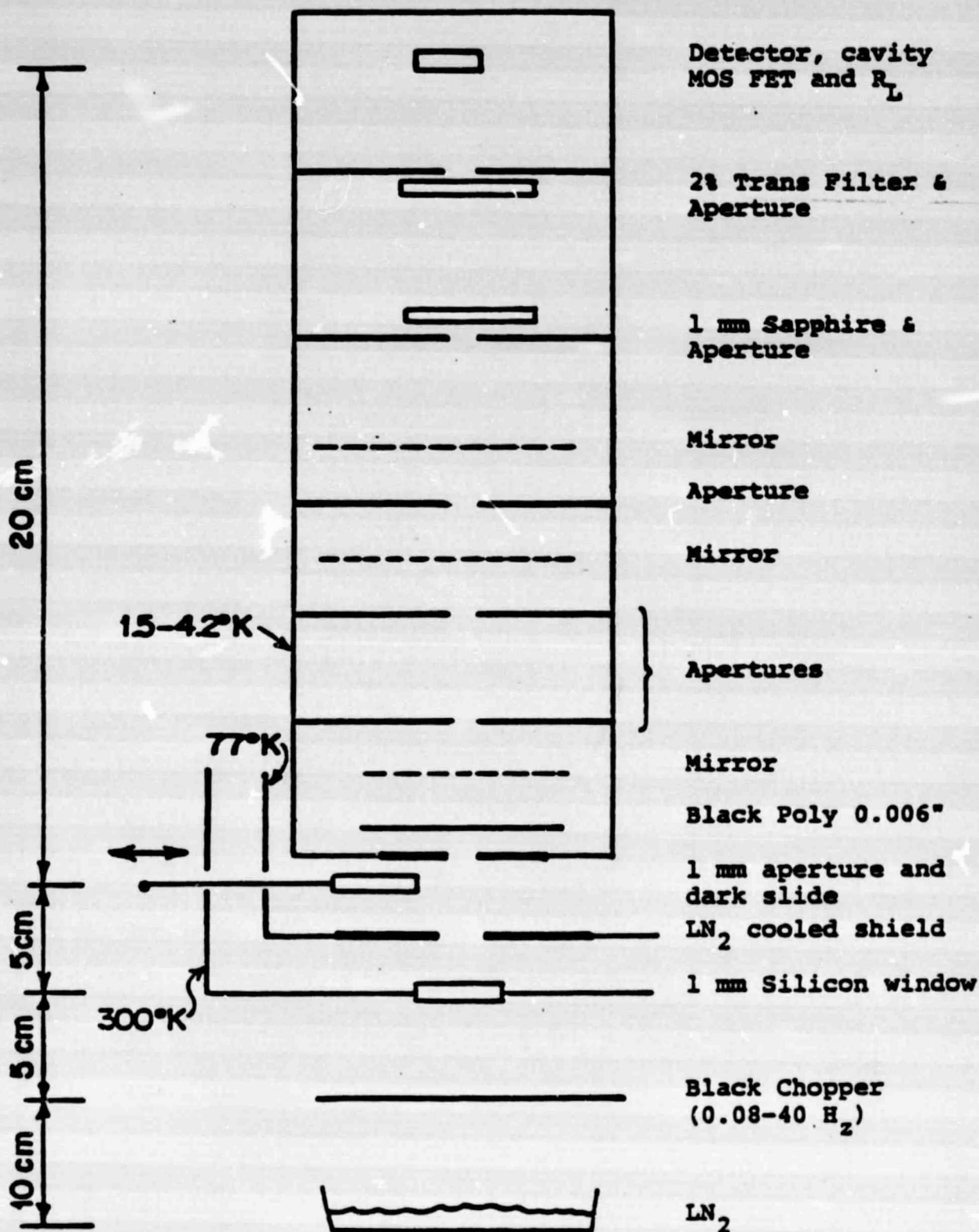
The Slide open powers were

	IN BAND	REFERRED TO 100 μ
OP I	$1.34 \times 10^{-12}_w$	$3.37 \times 10^{-13}_w$
OP II	$8.35 \times 10^{-13}_w$	$4.69 \times 10^{-13}_w$
OP III	2.69×10^{-13}	$1.59 \times 10^{-13}_w$



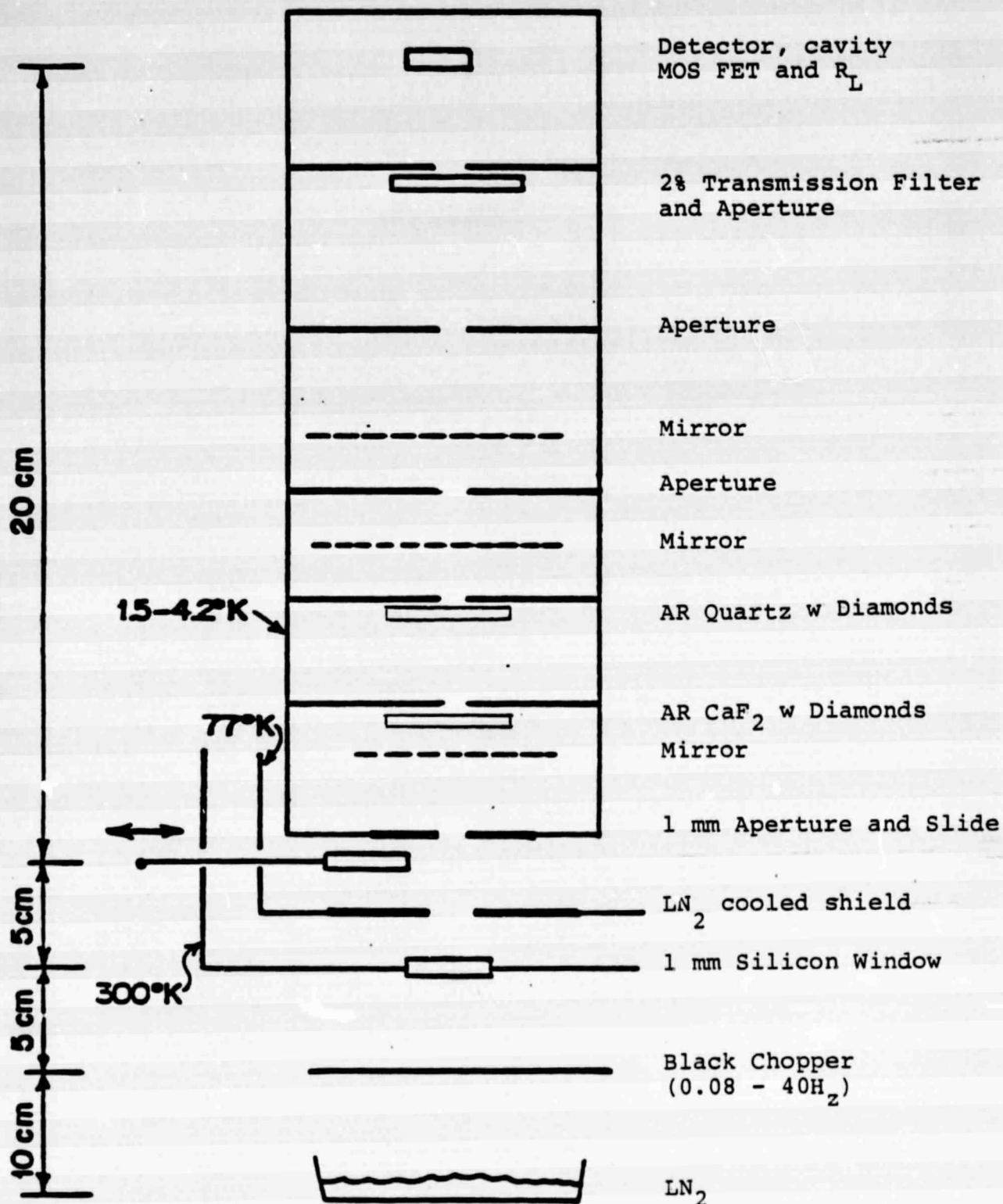
OPTICAL PATH (unfolded) OPI

CORNELL FILTERS



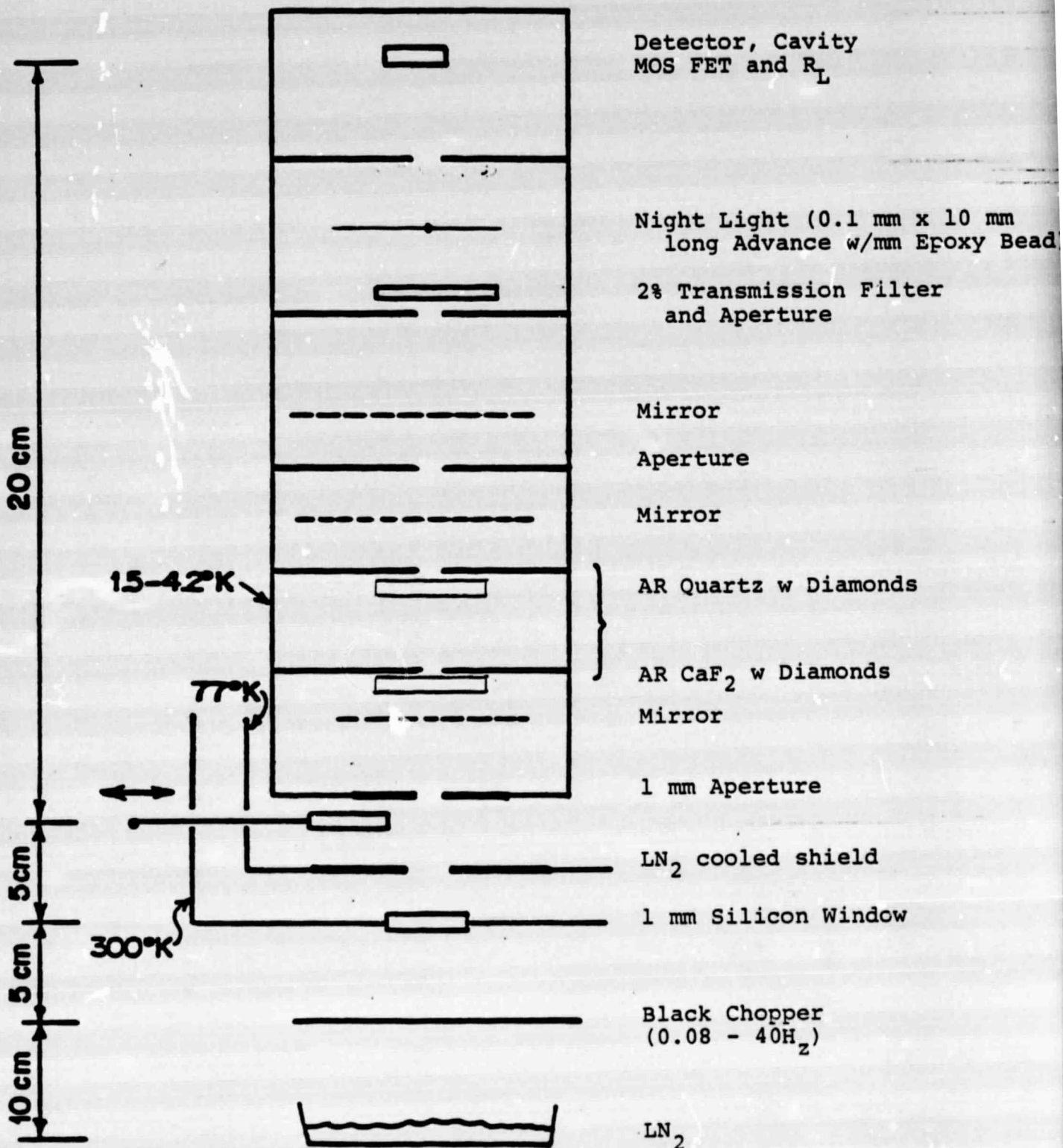
OPTICAL PATH (unfolded) OPII

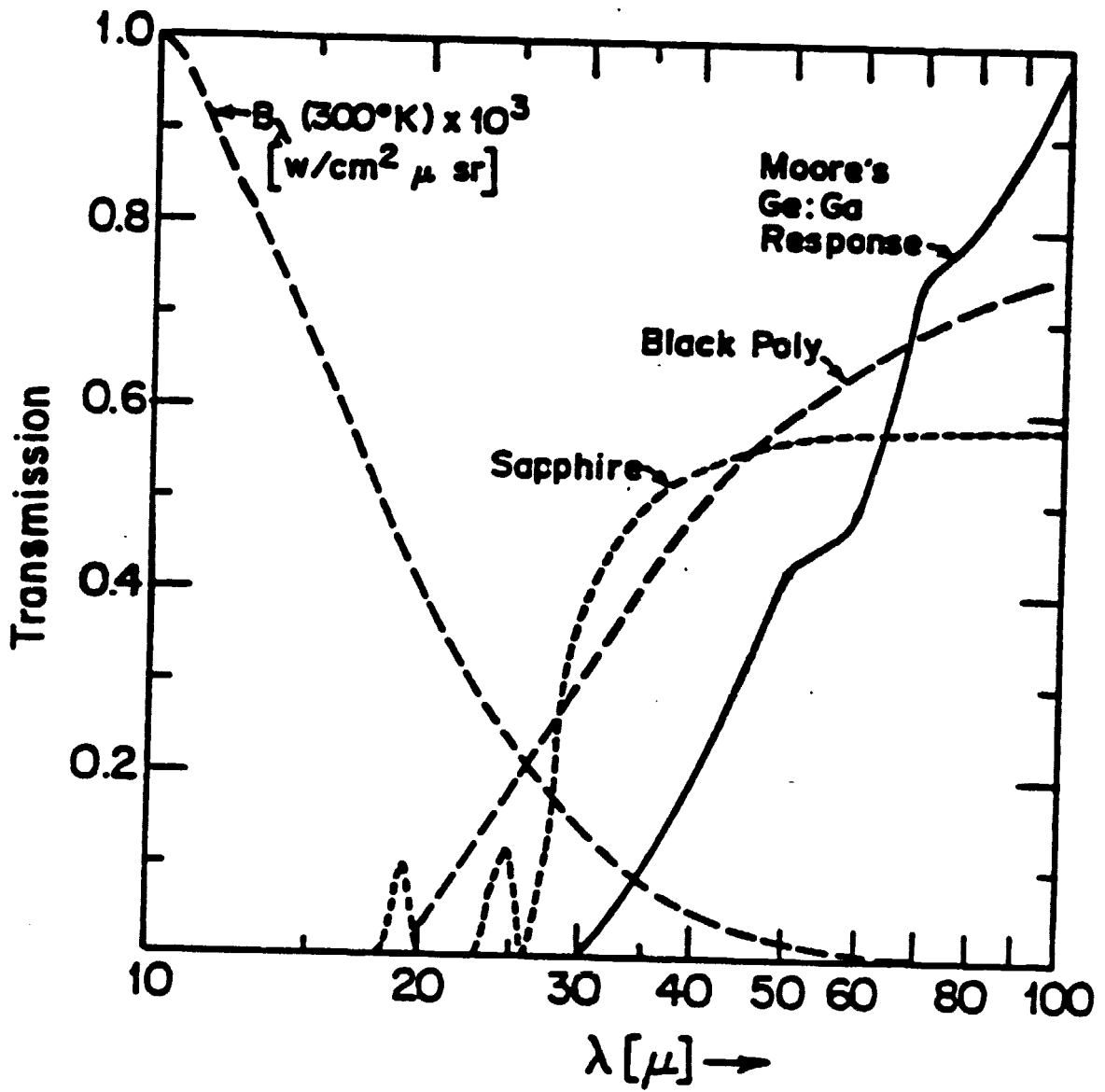
LOW'S FILTERS

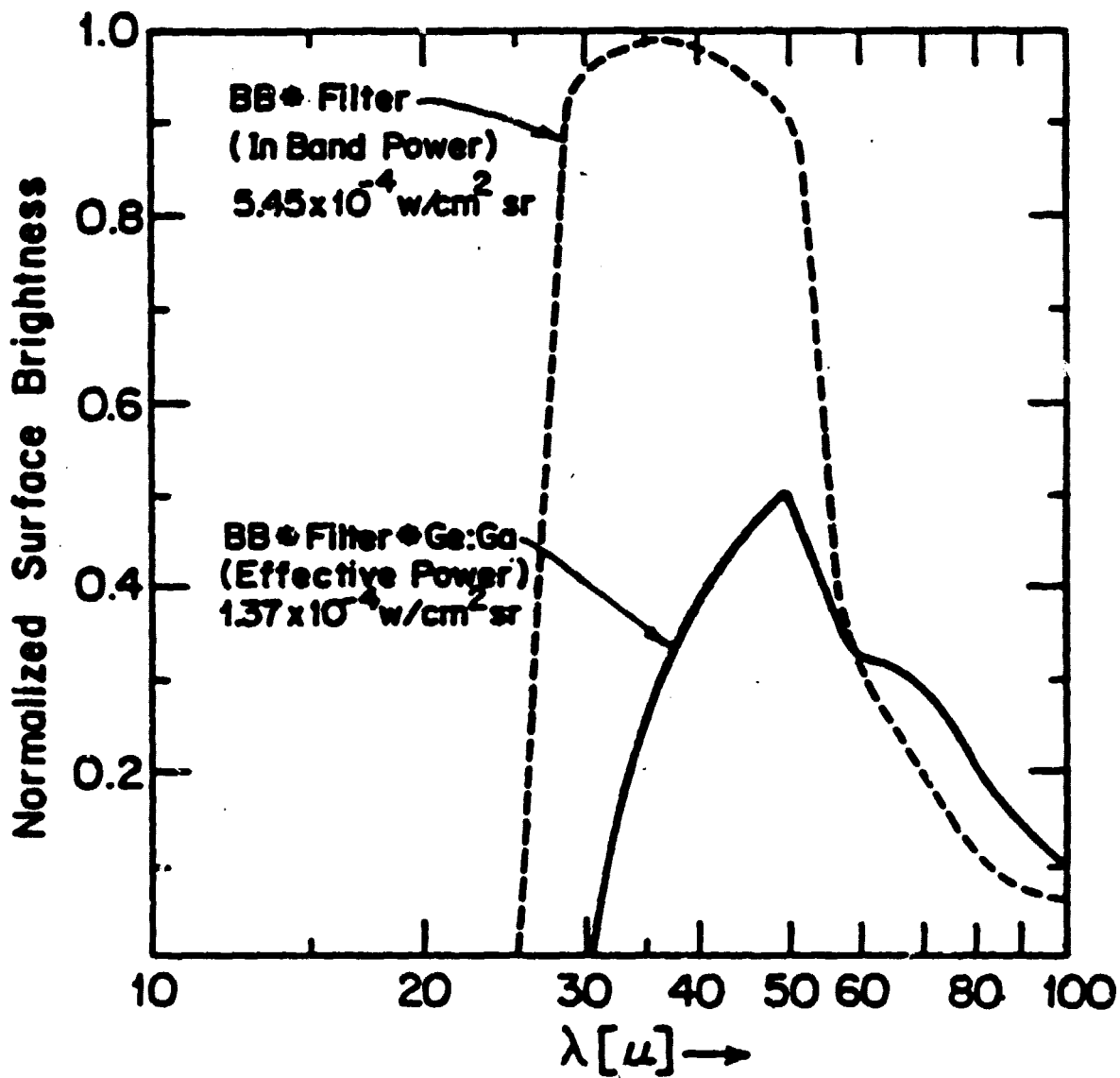


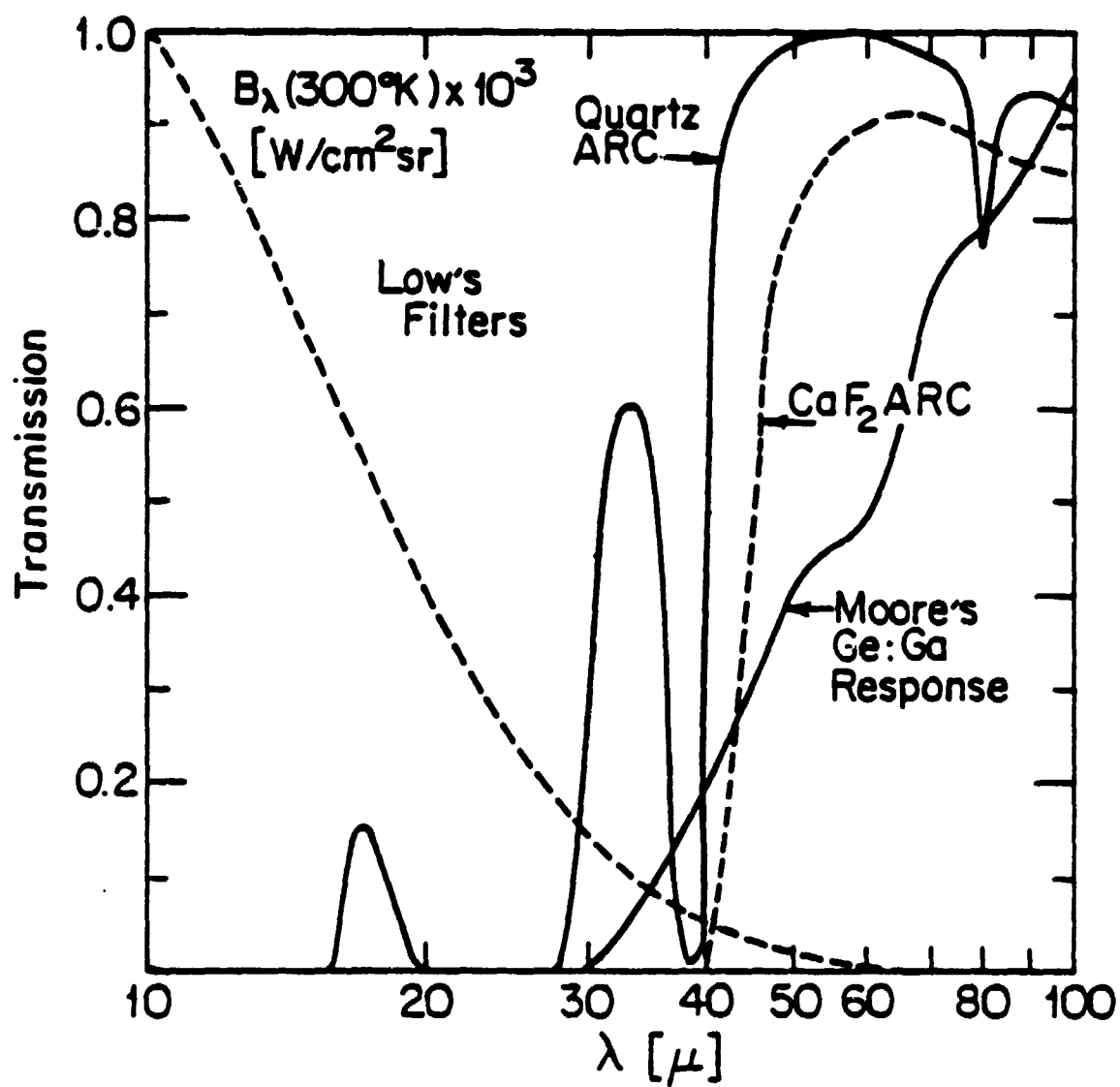
OPTICAL PATH (unfolded) OP III

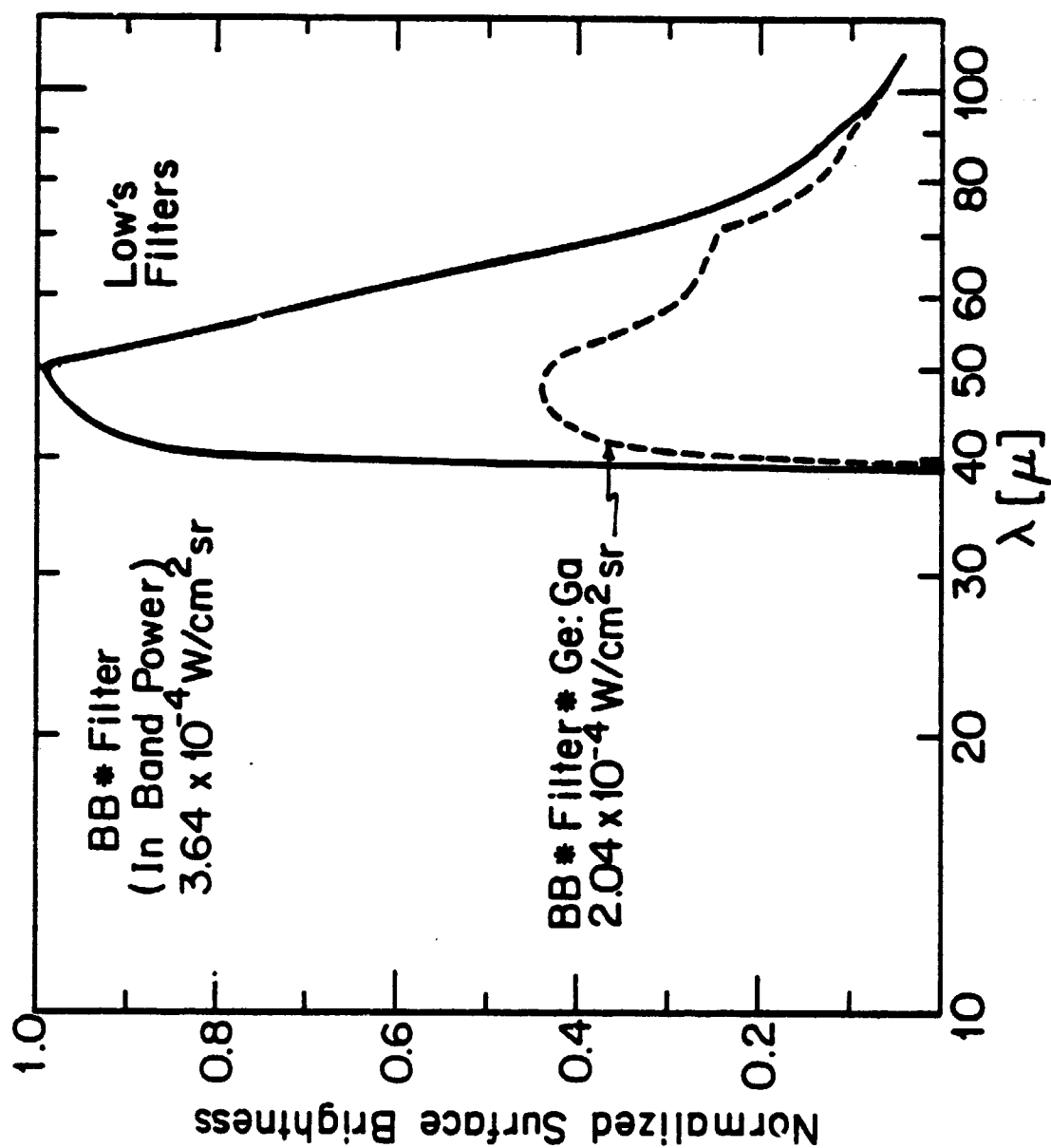
NIGHT LIGHT











ELECTRONICS

All tests were taken with a dual MOS FET TIA. A G118 was used with the body lead returned to the bottom of the source resistors (50K + 6.95 v) outside the Dewar.

R_L for the early OP I tests was a very non linear $\sim 4 \times 10^{10} \Omega$ Elec. For the later OP I and all OP II and III tests a very constant (10 mv < v < 1v) $3.6 \times 10^9 \Omega$ resistor was used. No "night light" or "warm FET" tricks were used.

ROCKWELL DETECTOR

IRD 1981

Band 4

witness Sample

Cavity SC016

Ge:Ga Xtal #3

Slice 24 (C2)

$\rho = 17.5 \Omega \text{ cm}$

Ion implanted contacts

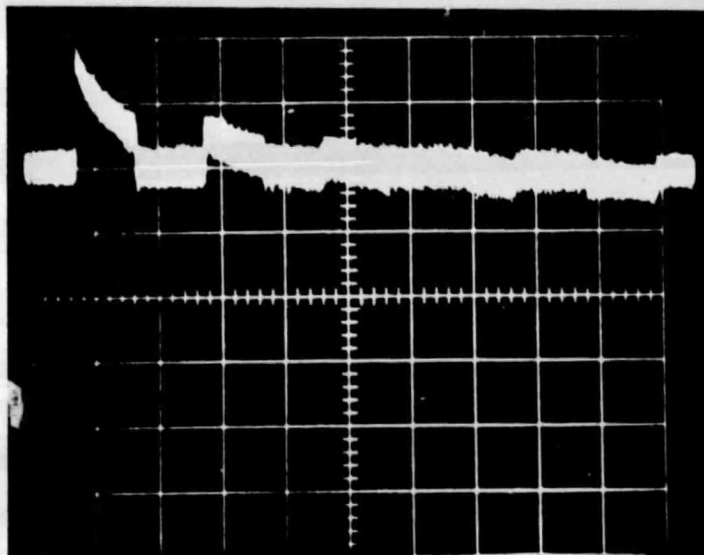
$0.0454 \times 0.06 \times 0.06 \text{ in}^3$

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IRD 1981
Bias turn on

$V_B = + 0.2 \text{ v}$
 $T = 1.8^\circ \text{ K}$

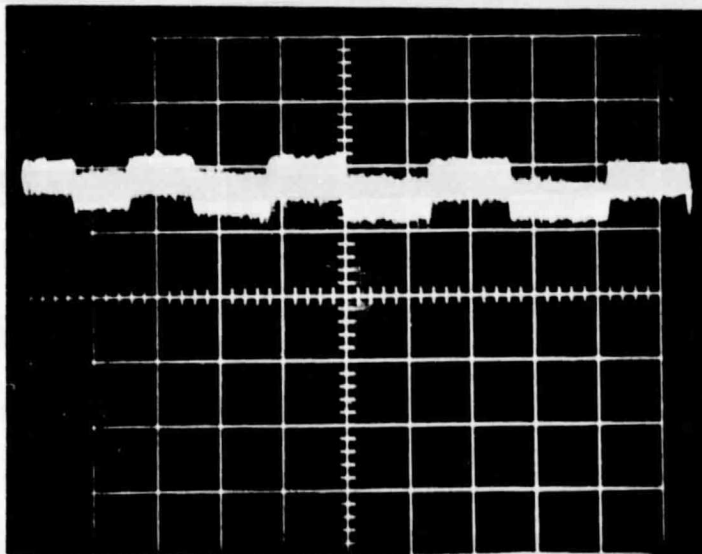
CL OP CL OP



Upward signal is first opening, about 5 sec after the bias was turned on

1 mV x 1 sec

CL OP CL OP CL



Later (1 - 2 minutes)

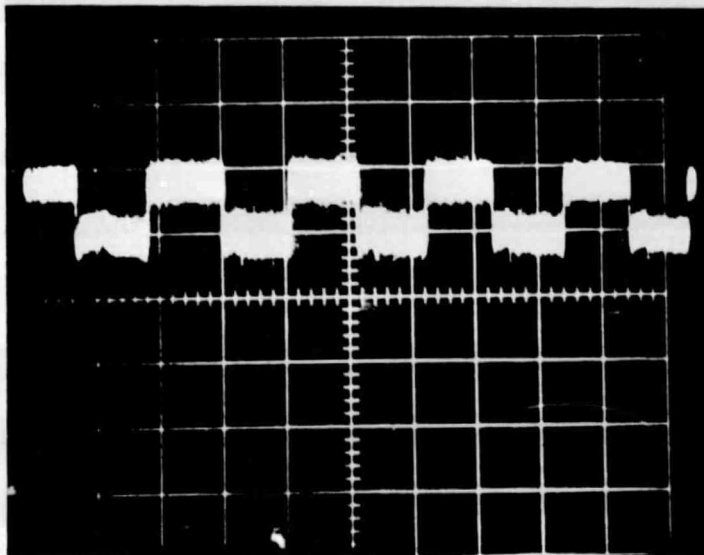
--Closed

--Open

→It takes time under illumination for bias to establish itself

Note: Signal went from large one way, to zero, then opposite sign

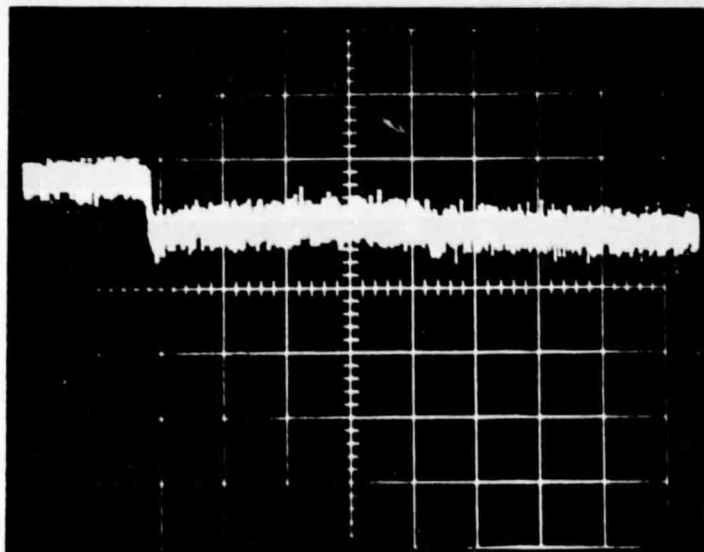
ORIGINAL PHOTO
OF POOR QUALITY



--Closed

--Open

1 mV x 1 sec

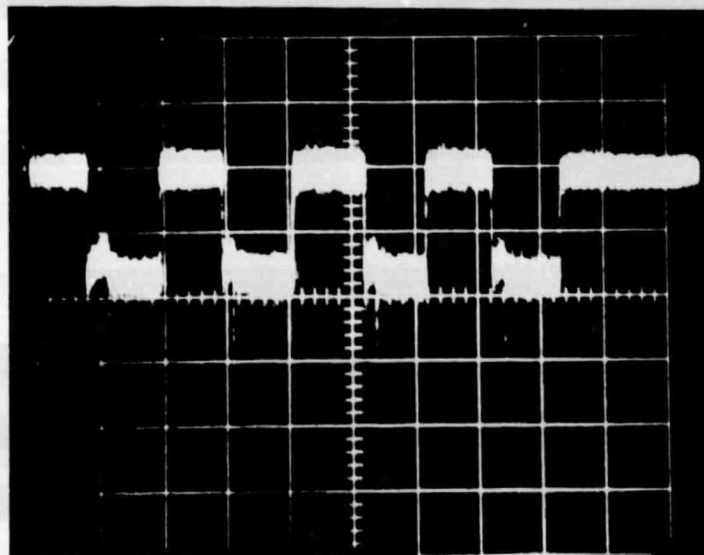


--Closed

--Open

1 mV x 0.1 sec

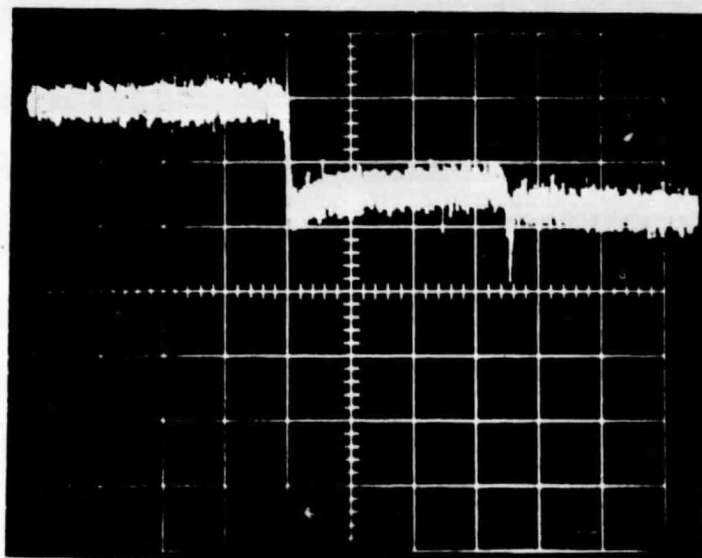
ORIGINAL PAGE IS
OF POOR QUALITY



--Closed

--Open

1 mV x 1 sec



--Closed

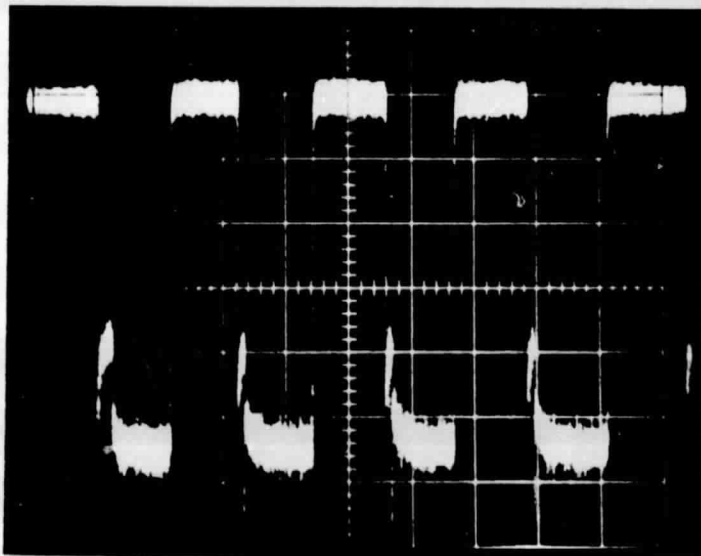
--Open

1 mV x 0.1 sec

↑ ~0.36 sec ↑

Note: Spike at delayed Transition

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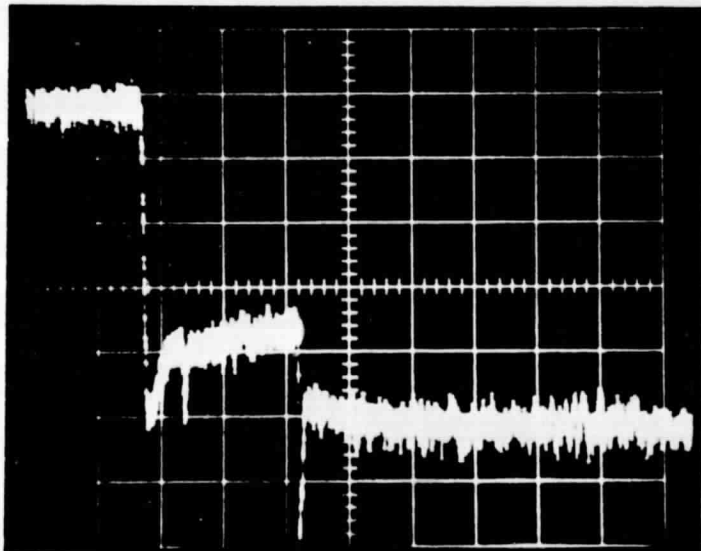


--Closed

Note: On successive cycles, the glitch comes sooner each time. Also note the delayed transition has an associated spike each time

--Open

1 mV x 1 sec



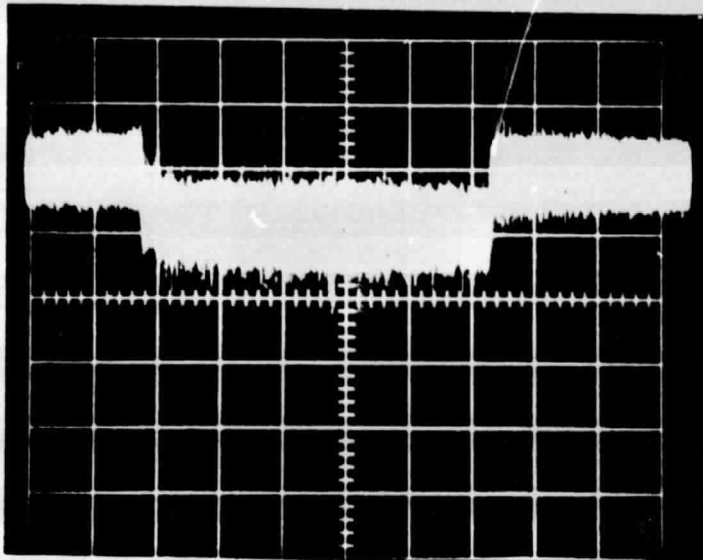
1 mV x 0.1 sec

↑ ~0.26 sec ↓

Spike at Transition.

Time delay from opening decreases with increasing bias.

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OF POOR QUALITY

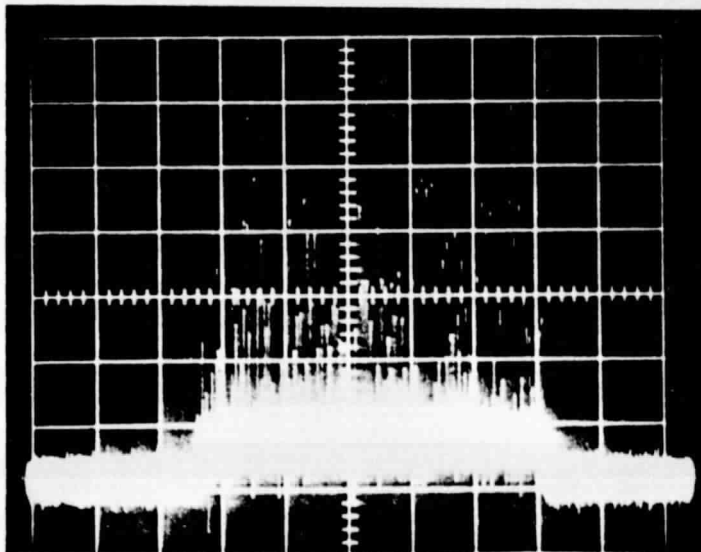


$$V_B = + 0.40$$

--Closed (positive cavity)

--Open

5 mV x 0.5 sec



10 mV x 0.5 sec

$$V_B = - 0.40$$

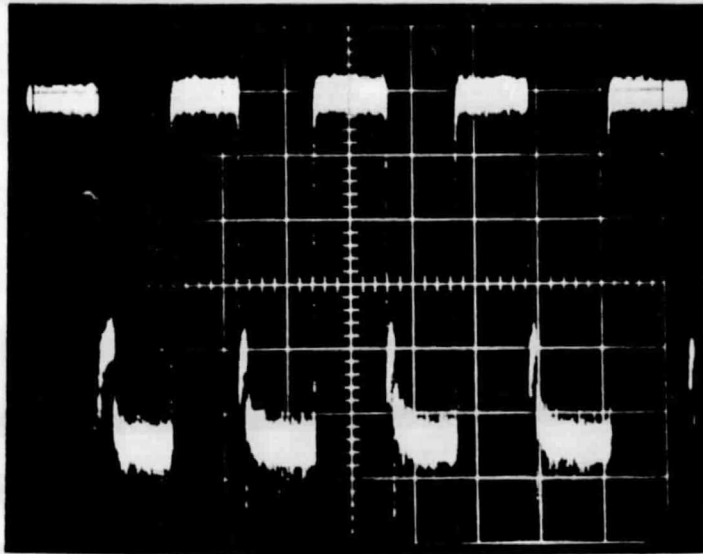
(negative cavity)

--Open

--Closed

Note: Taken 18 Jan. with old (pass $\lambda > 30 \mu$) optical filters and wide Bandwidth electronics

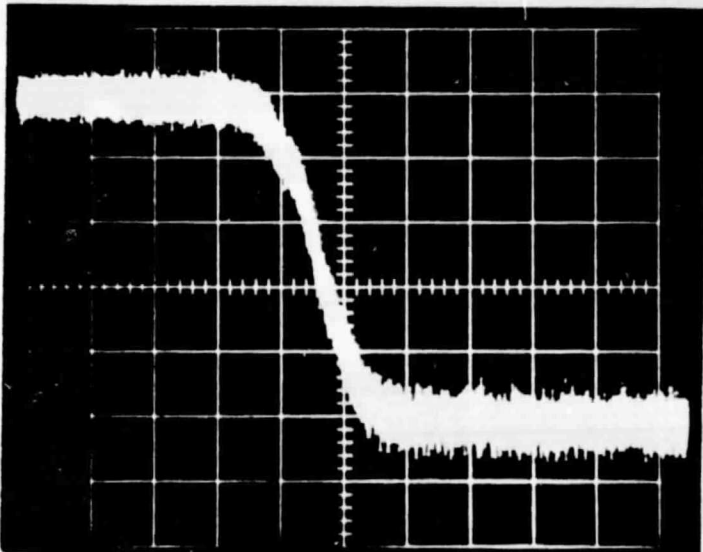
Unless noted, all other traces have 110 Hz (3 dB/Octave) single pole RC filtering.



--Closed Fast Opening:

--Open

1 mV x 1 sec

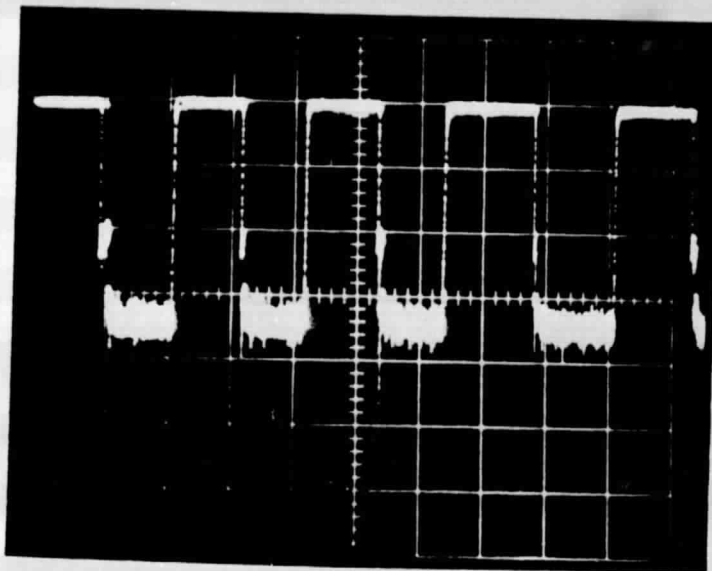


Slow Opening

1 mV x 0.5 sec

Fairly smooth, no obvious transition jump or spike

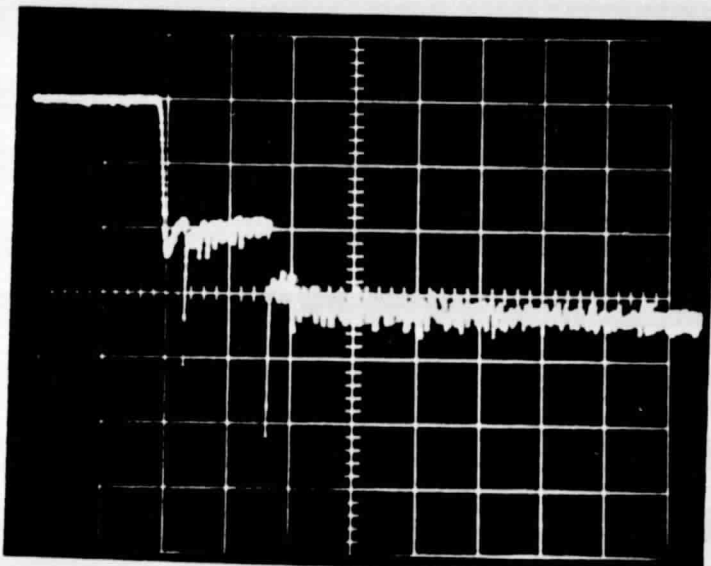
ORIGINAL PAGE IS
OF POOR QUALITY



--Closed

--Open

5 mV x 1 sec



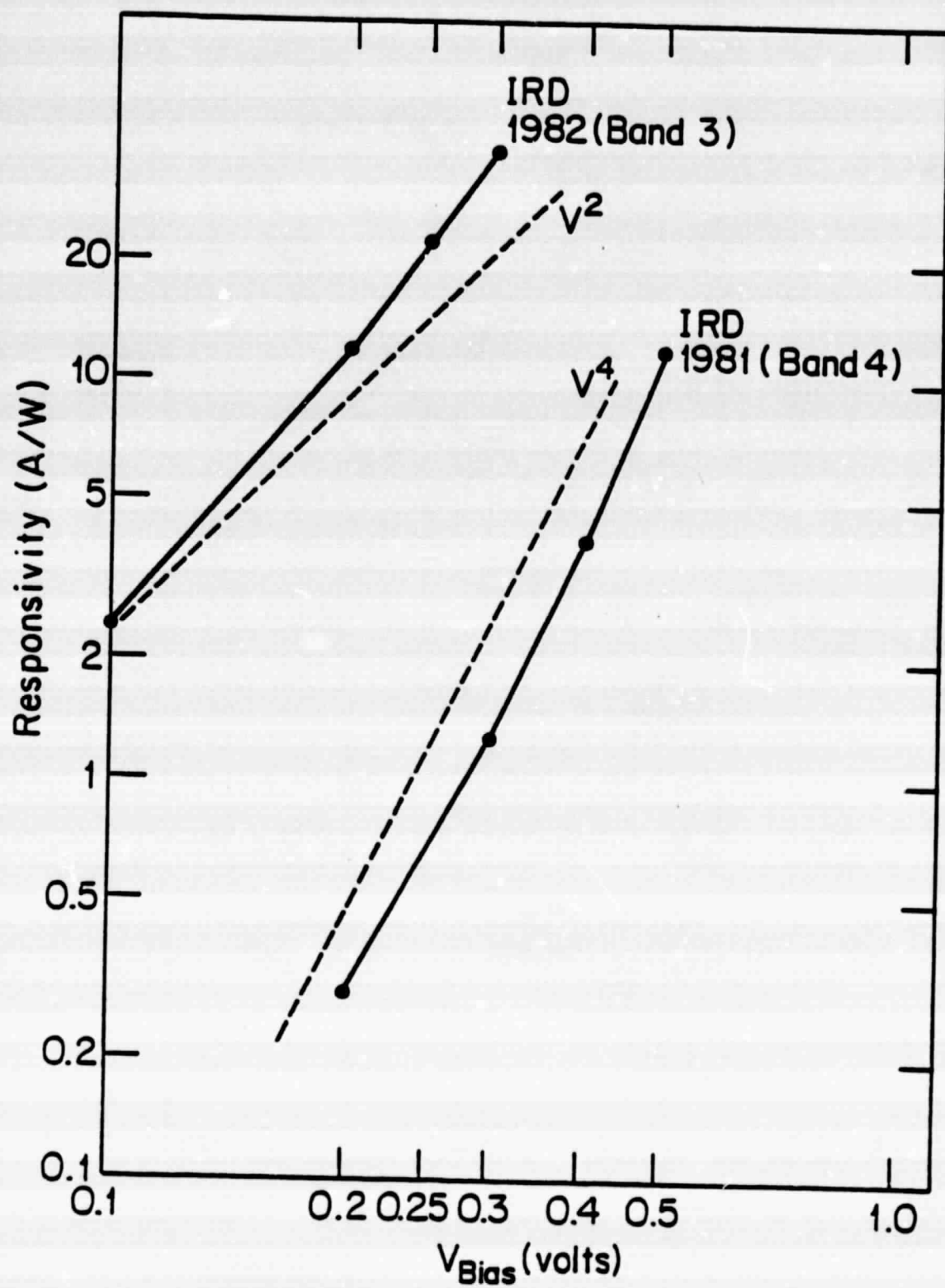
--Closed

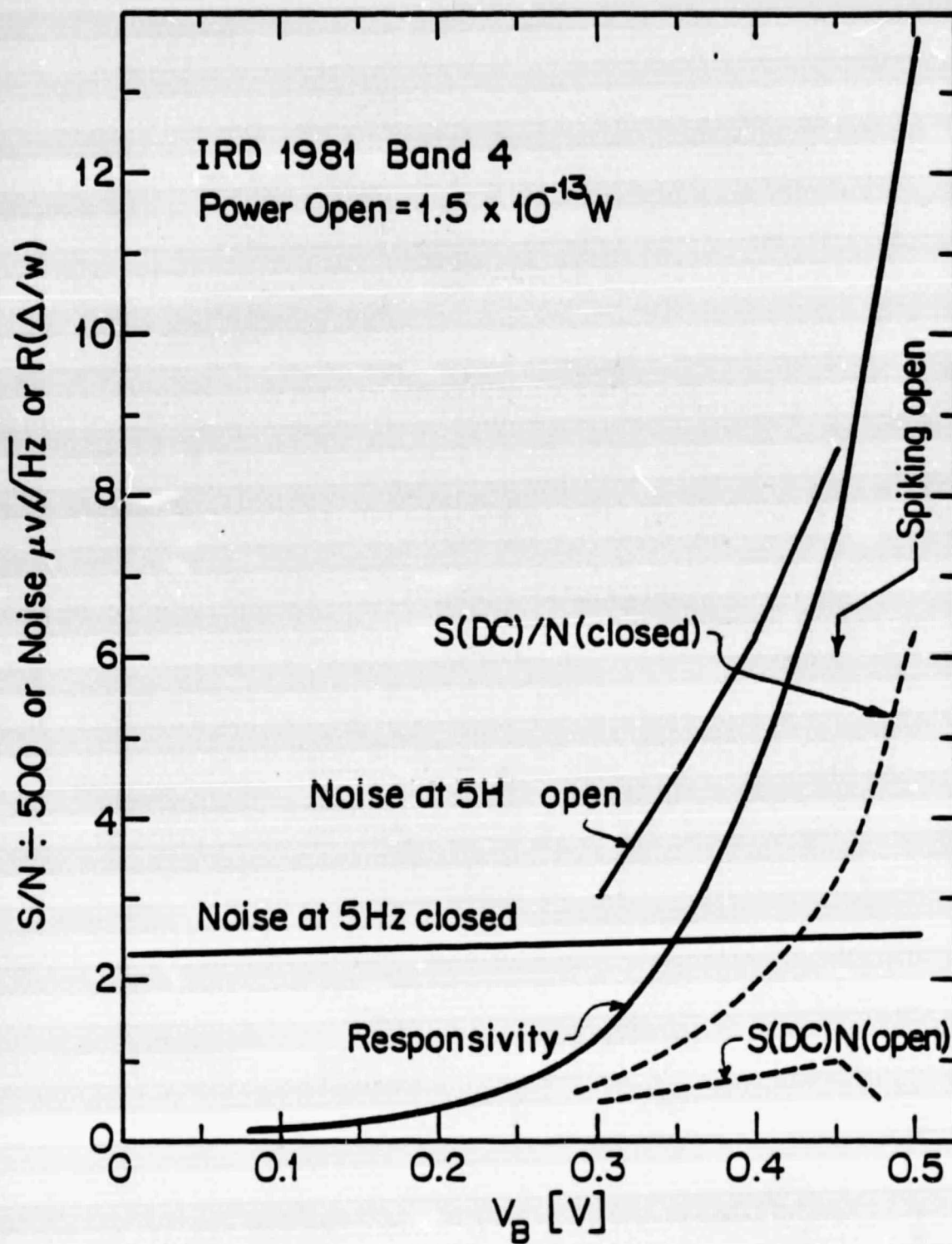
--Open

5 mV x 0.1 sec

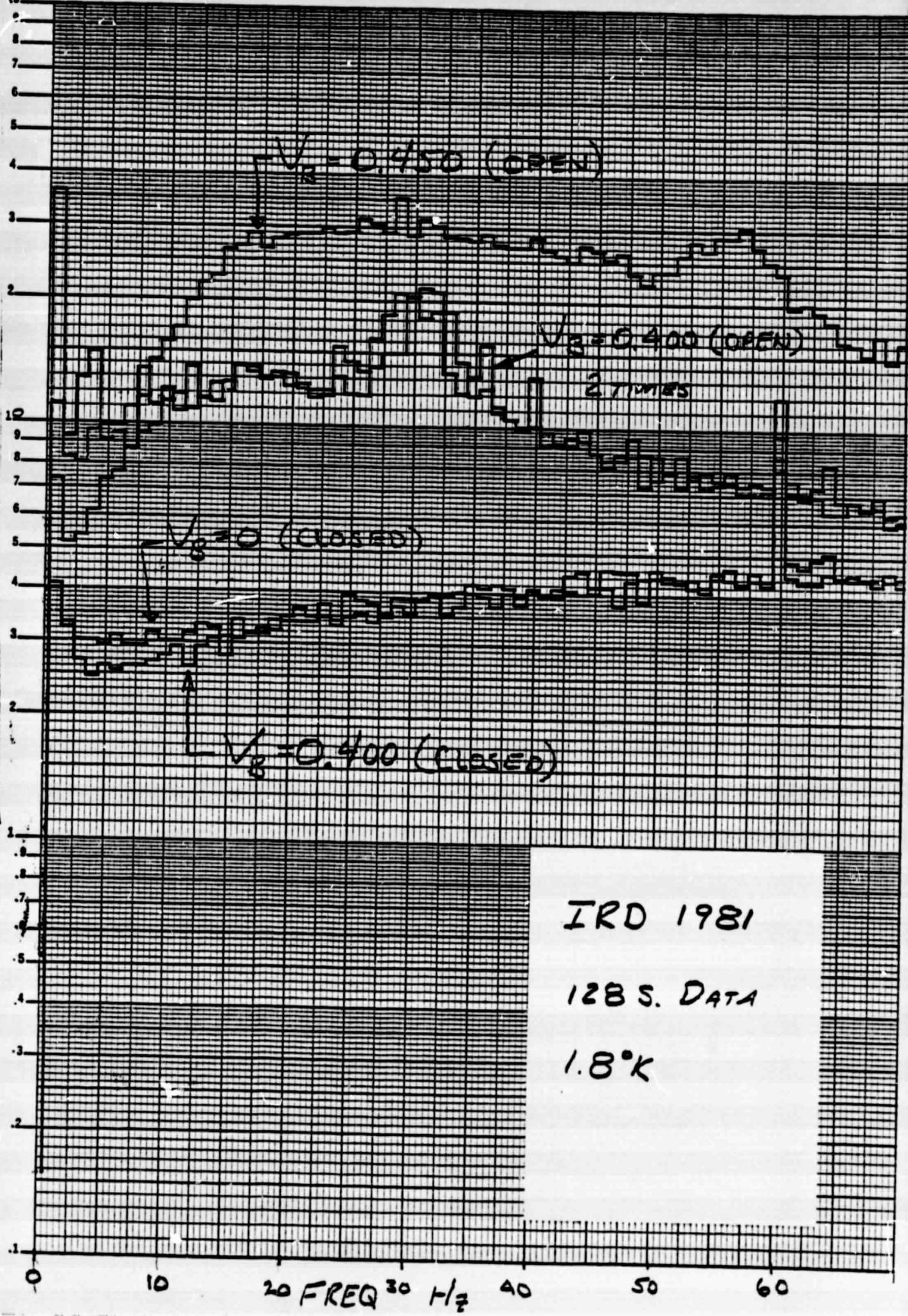
↑
~ 0.18 sec

Spike





Noise $[\mu v/\sqrt{Hz}]$



IRD 1981

128 S. DATA

1.8°K

ROCKWELL DETECTOR

IRD 1982

Band 3

Witness Sample

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Cavity SC017

Ge:Ga Xtal #3

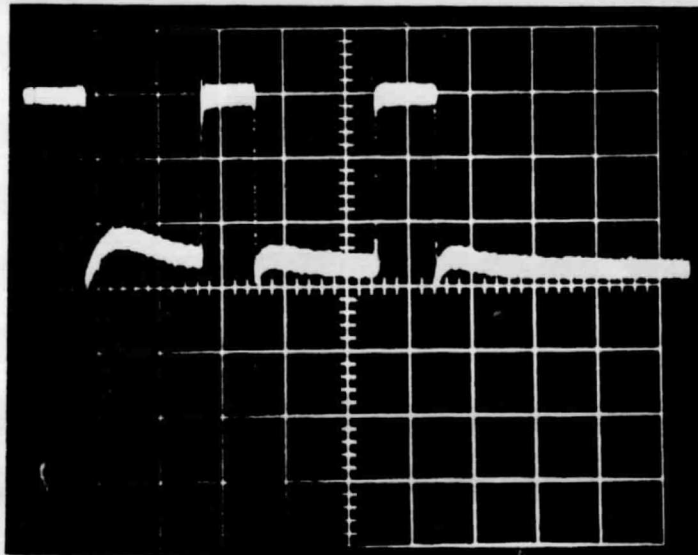
Slice 25(E6)

$\rho = 16.9 \Omega \text{ cm}$

Ion. Implanted Contacts

0.040 x 0.040 x 0.040 in³

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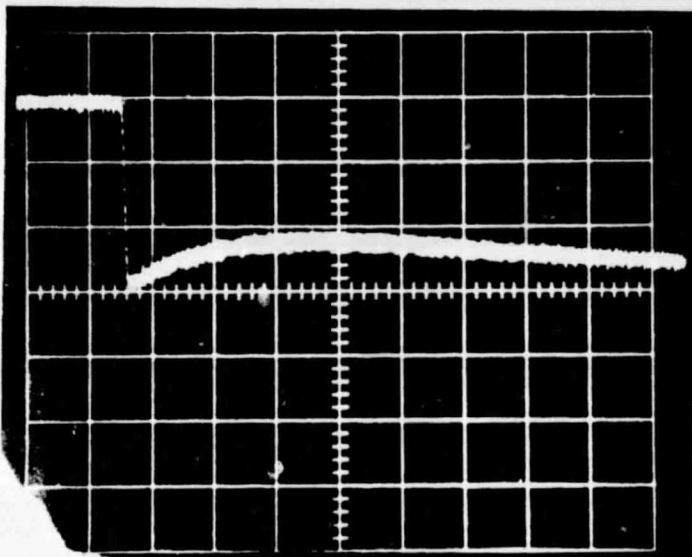


--Closed ("Dark")

--Open ("Light")

2 mV x 1 sec

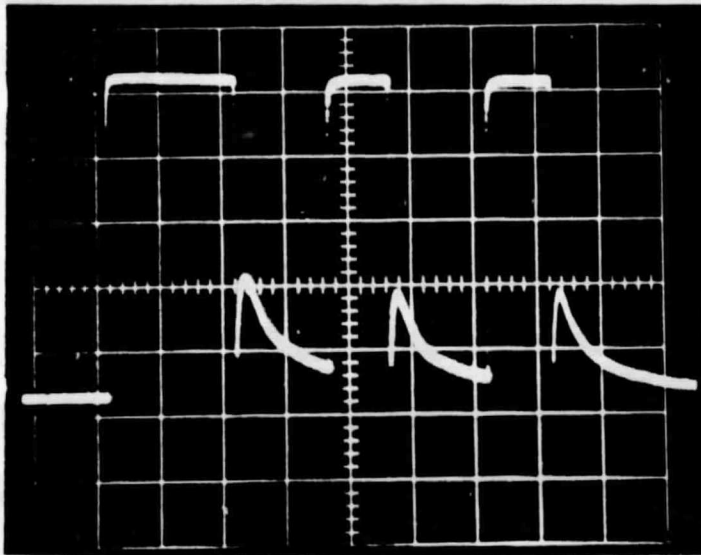
Note decrease in hook in later openings



--Closed

--Open

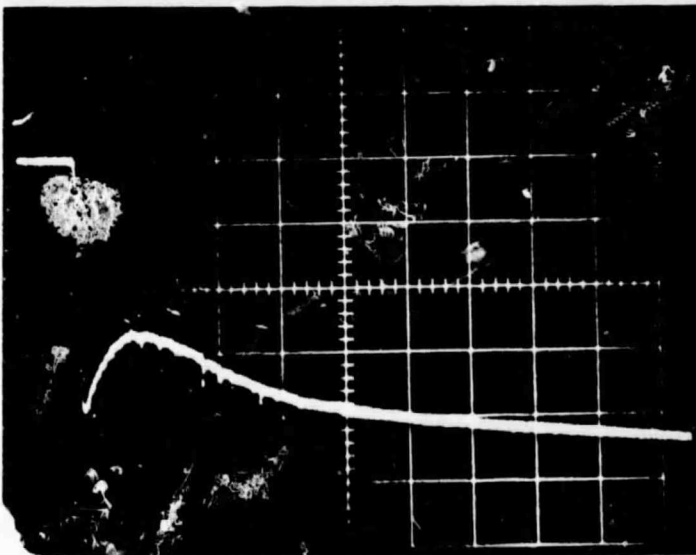
2 mV x 0.2 sec

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OF POOR QUALITY

--Closed

--Open

5 mV x 1 sec



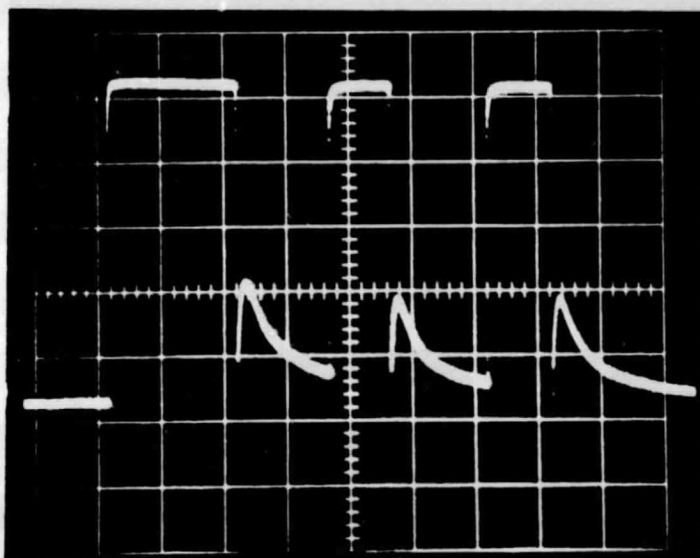
--Closed

--Open

5 mV x 0.2 sec

Hook is faster at higher bias

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OF POOR QUALITY



--Closed

$V_B = + 0.20$
(positive cavity)

--Open

5 mV x 1 sec

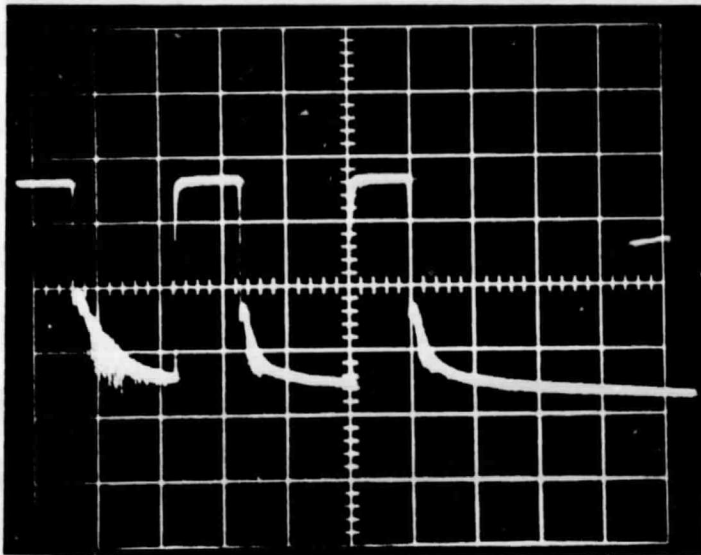


--Open

$V_B = - 0.20$
(negative cavity)

--Closed

Approximately Symmetric, but slightly better with
positive cavity



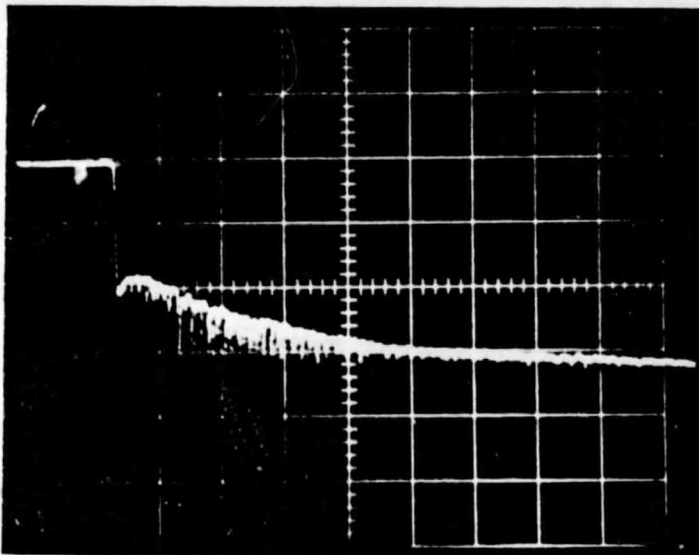
ORIGINAL PAGE IS
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--Closed

--Open

20 mV x 1 sec

Higher bias $\rightarrow$ Spiking on opening

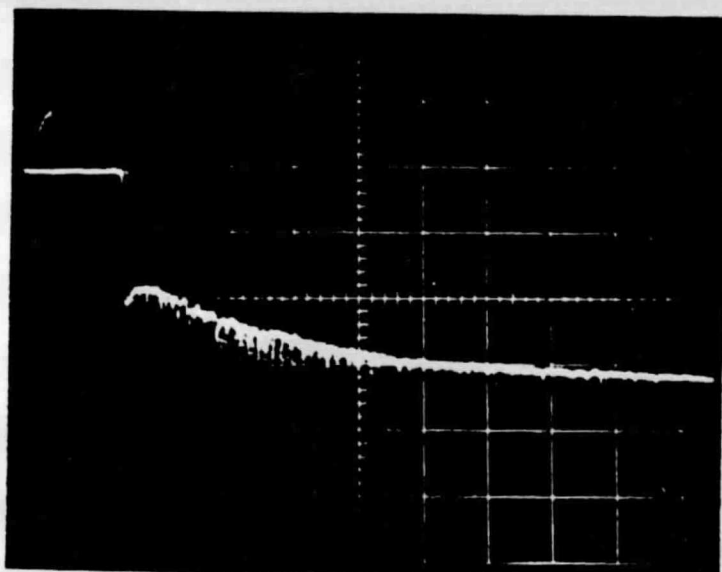


--Closed

--Open

20 mV x 0.2 sec

Note: Spiking decreases in later openings
Greatest spiking after prolonged period in the dark



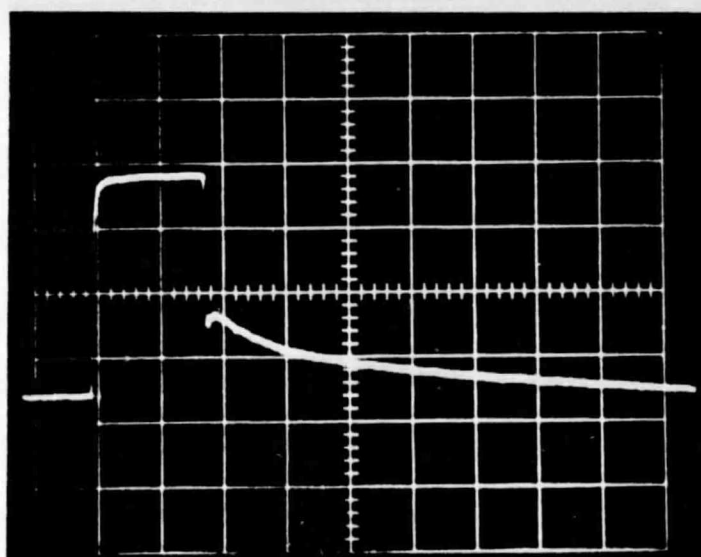
--Closed

--Open

20 mV x 0.2 sec

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← Long dark time
(6-10 sec)



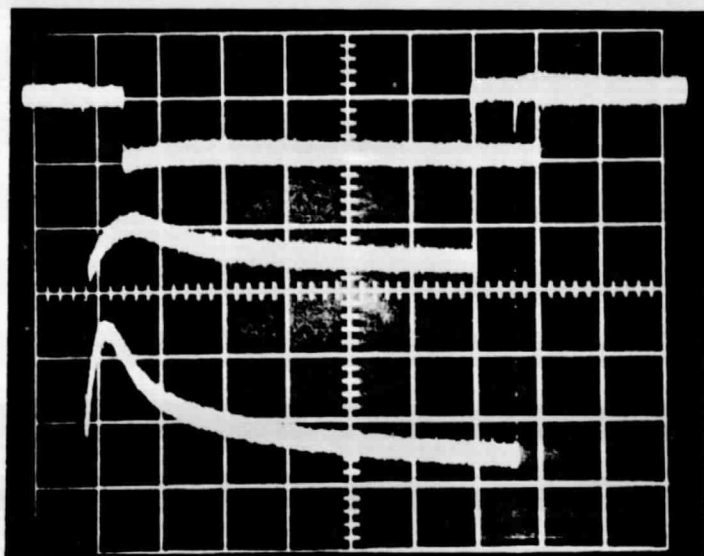
--Closed

--Open

open-

Short dark time

→ Spikes disappear if only dark for a short time



--Closed, all biases

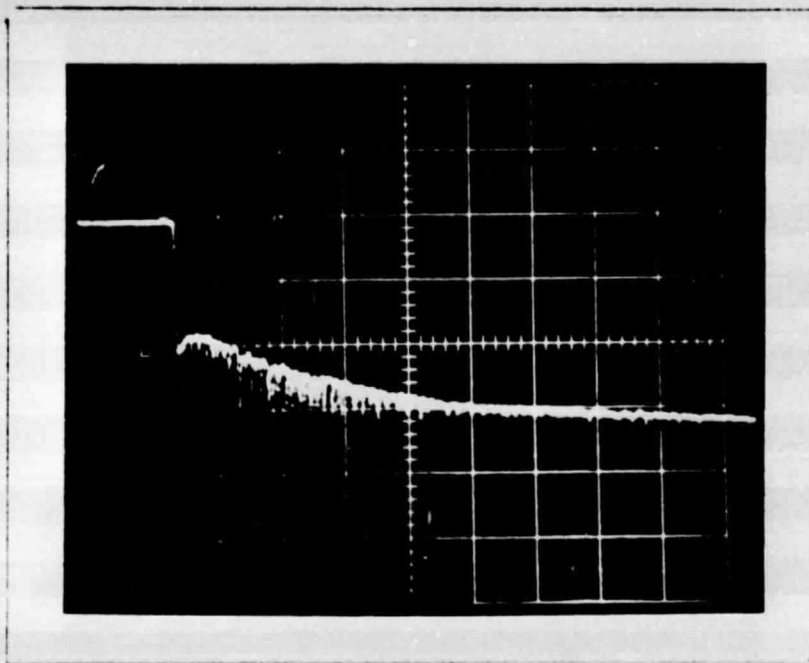
--Open, $V_B = + 0.05$

--Open, $V_B = + 0.10$

--Open, $V_B = + 0.15$

2 mV x 1 sec

Hook gets bigger and faster with increasing bias

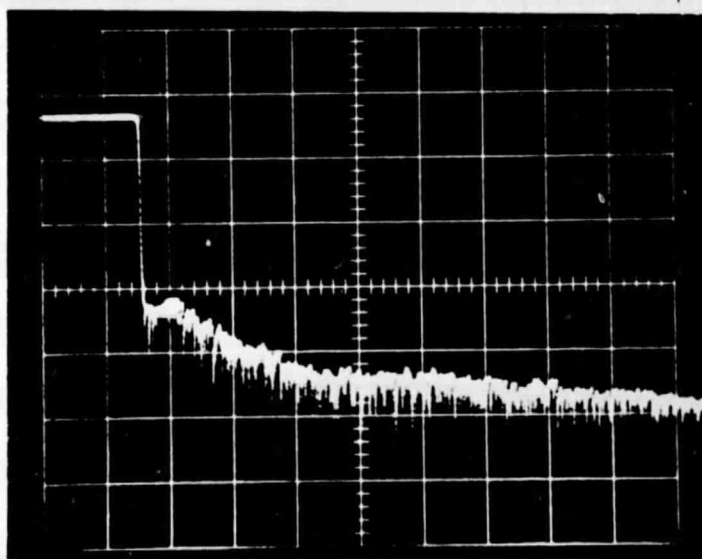


IRD 1982

$V_B = + 0.30$

1/30/79

20 mV x 0.2 sec



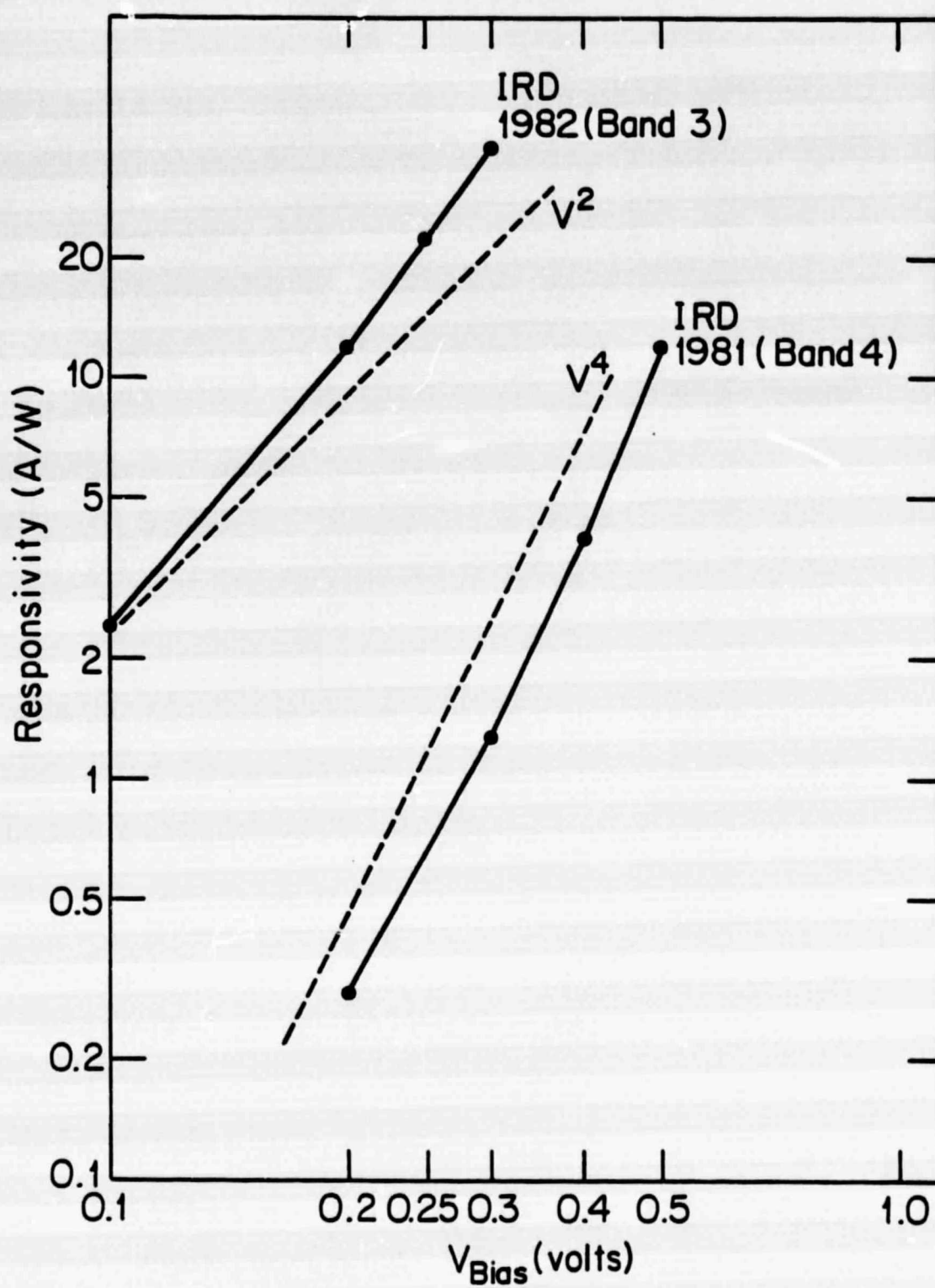
Berkeley Detector

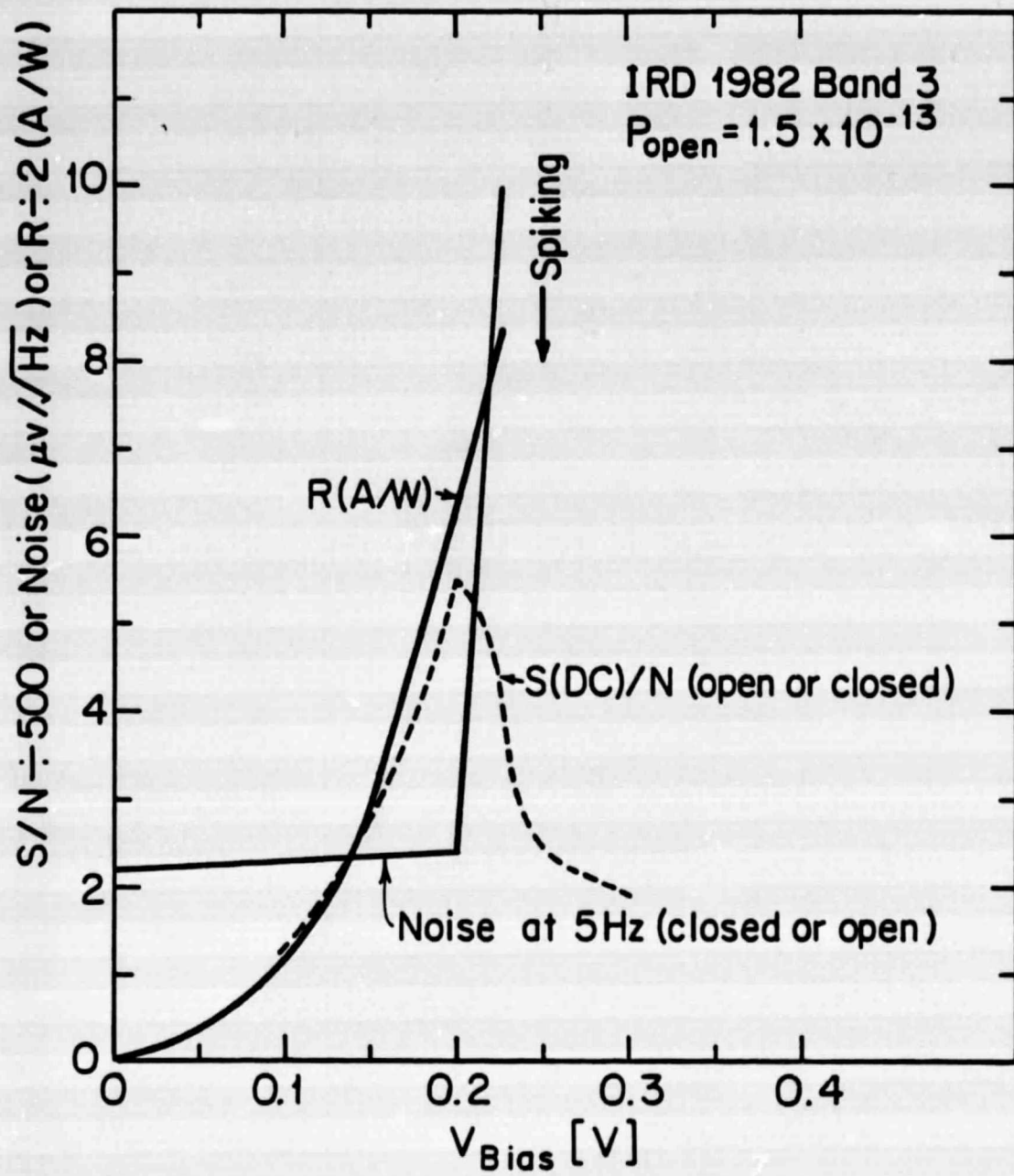
$V_B = + 0.20$

8/4/78

50 mV x 0.5 sec

Note: Band #3 Rockwell looks very much like an early Berkeley detector





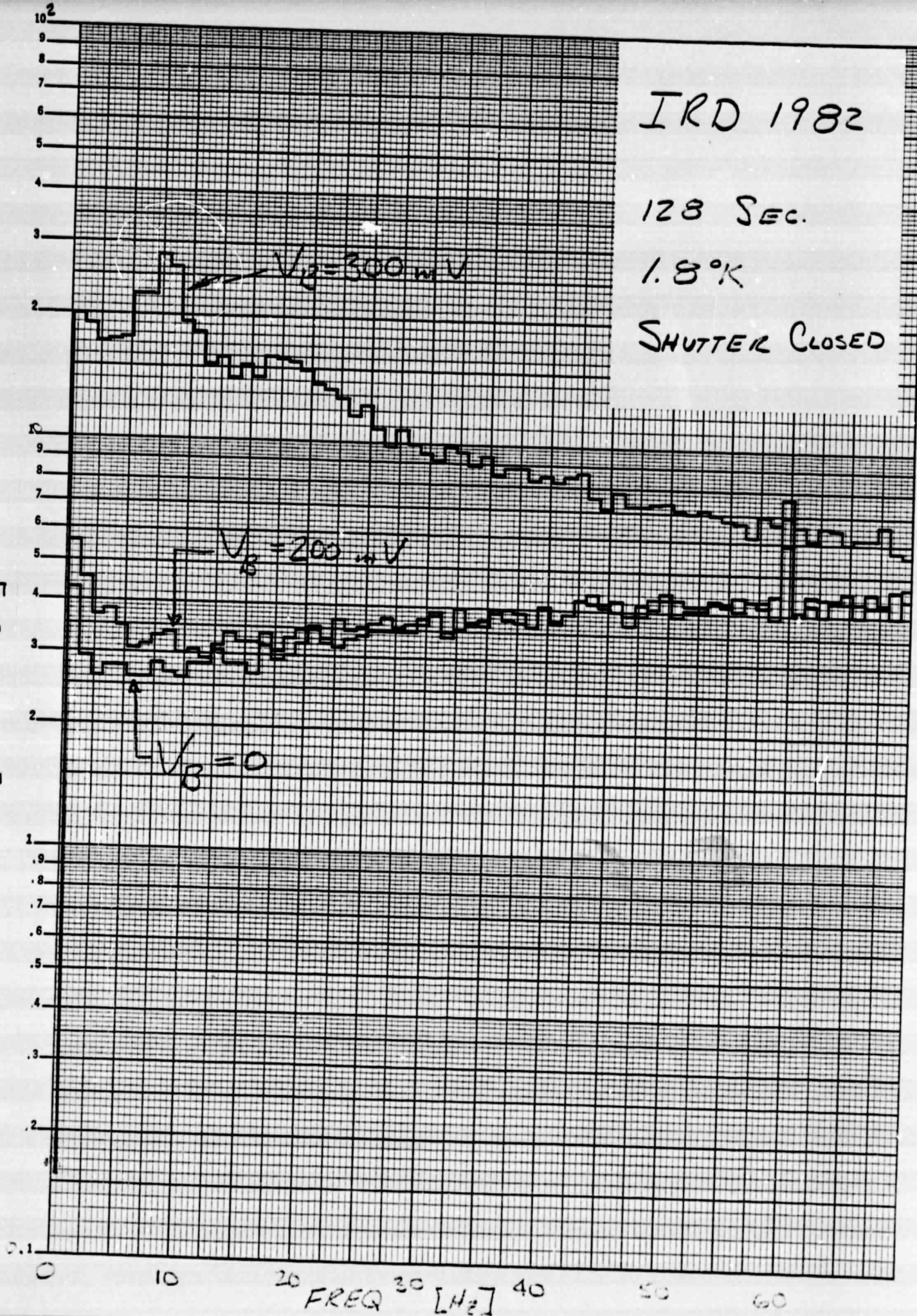
IRD 1982

128 SEC.

1.8°K

SHUTTER CLOSED

$\left[\frac{\mu^2}{\text{Hz}} \right]_{510\text{N}}$



IRD 1982

128 SEC. OF DATA

1.8°K

SHUTTER OPEN

Noise [$\mu V/\sqrt{Hz}$]

$V_B = 0.2$ SHUTTER OPEN

$V_B = 0.2V$ SHUTTER CLOSED

$V_B = 0.0$

0.1

10

20

30

40

50

60

FREQ [Hz]

Linearity Tests on

IRD 1982

Night Light

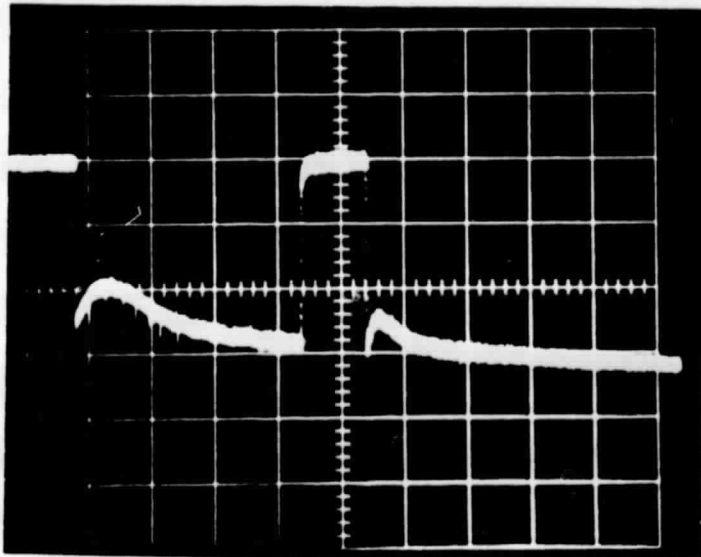
Power open = 1.5×10^{-13}

Low's Filters

$$V_B = 0.2 \text{ v}$$

$$T = 1.8^\circ \text{ K}$$

$$\Delta P (\text{Open-Closed}) = 1.5 \times 10^{-13} \text{ w @ } 100 \mu$$



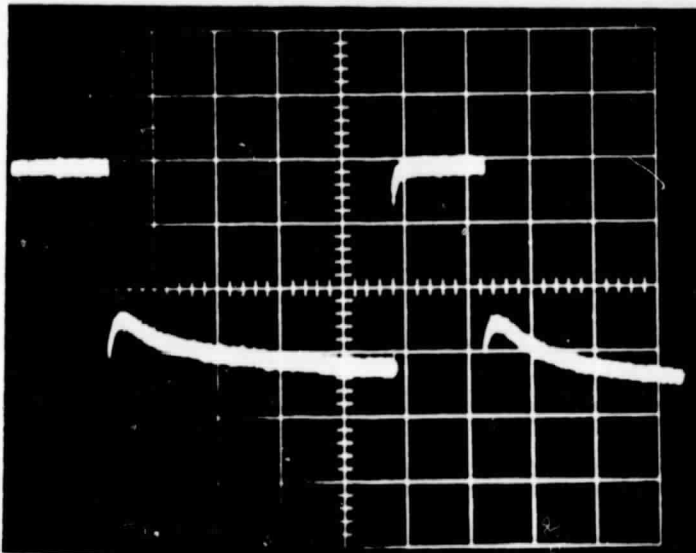
Night light off

--Closed

--Open

2 mV x 1 sec

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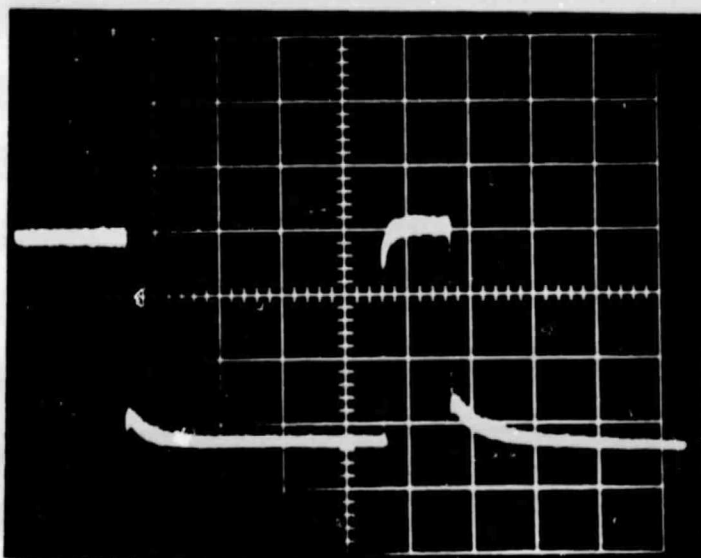


P(night light) =
10% of open slide =
 $1.5 \times 10^{-14} \text{ w}$
effective @ 100μ

$$V_B = 0.2$$

$$T = 1.8^\circ \text{ K}$$

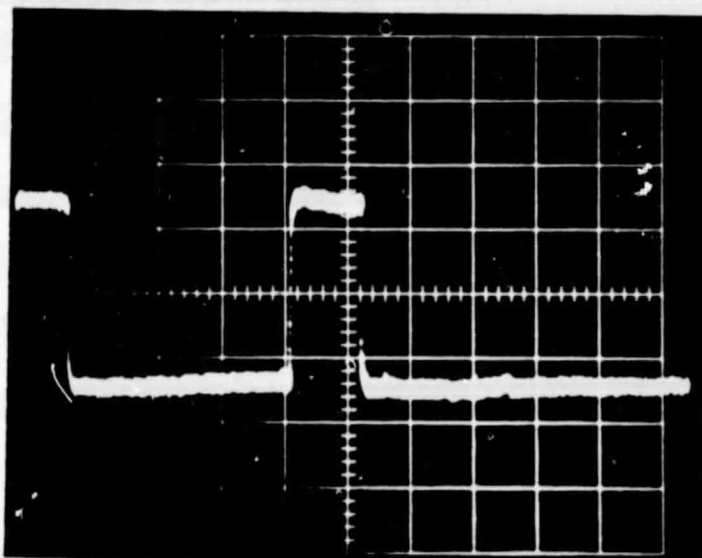
$$\Delta P = 1.5 \times 10^{-13} \text{ W @ } 100\mu$$



P (night light)

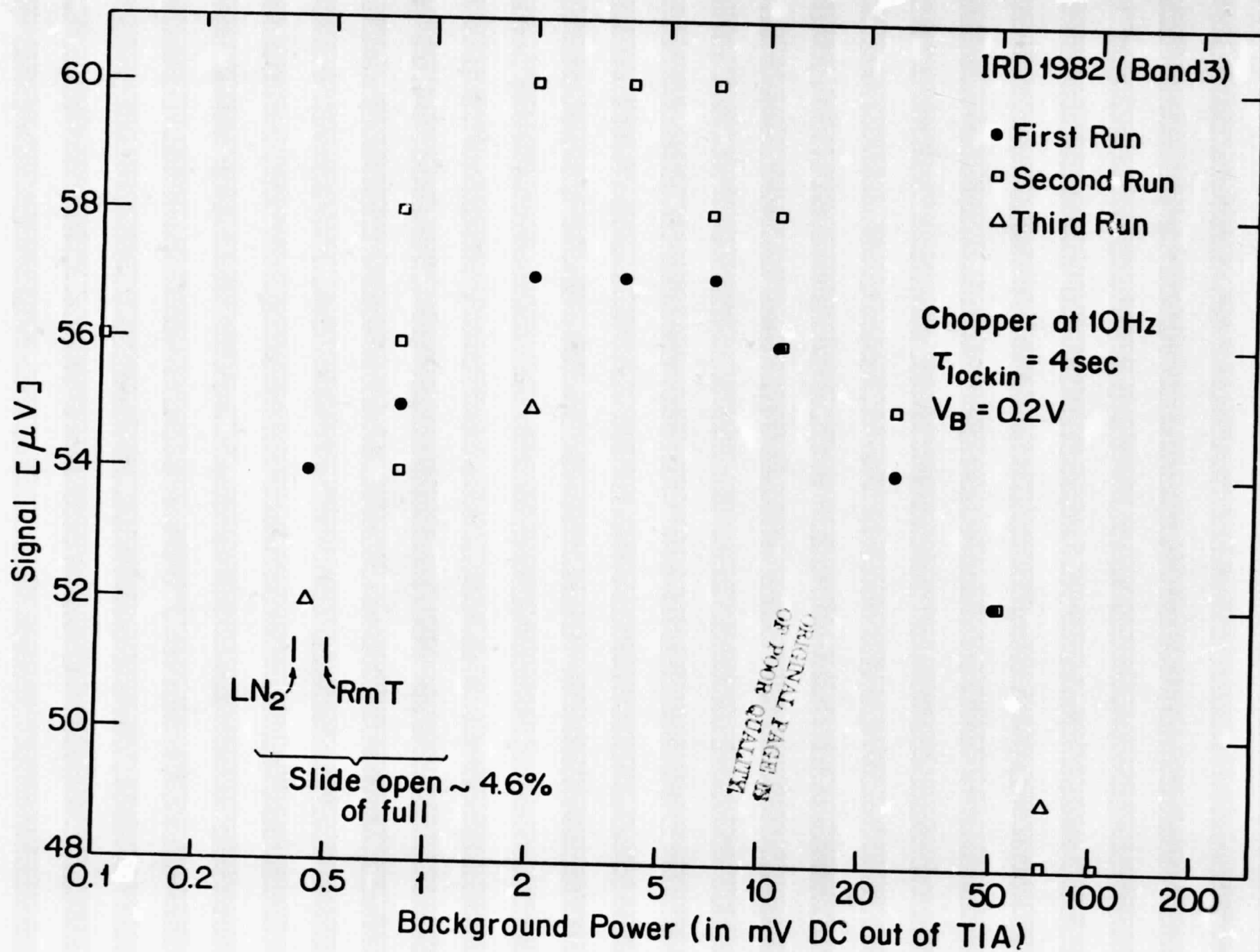
$$= 1.5 \times 10^{-13} \text{ W}$$

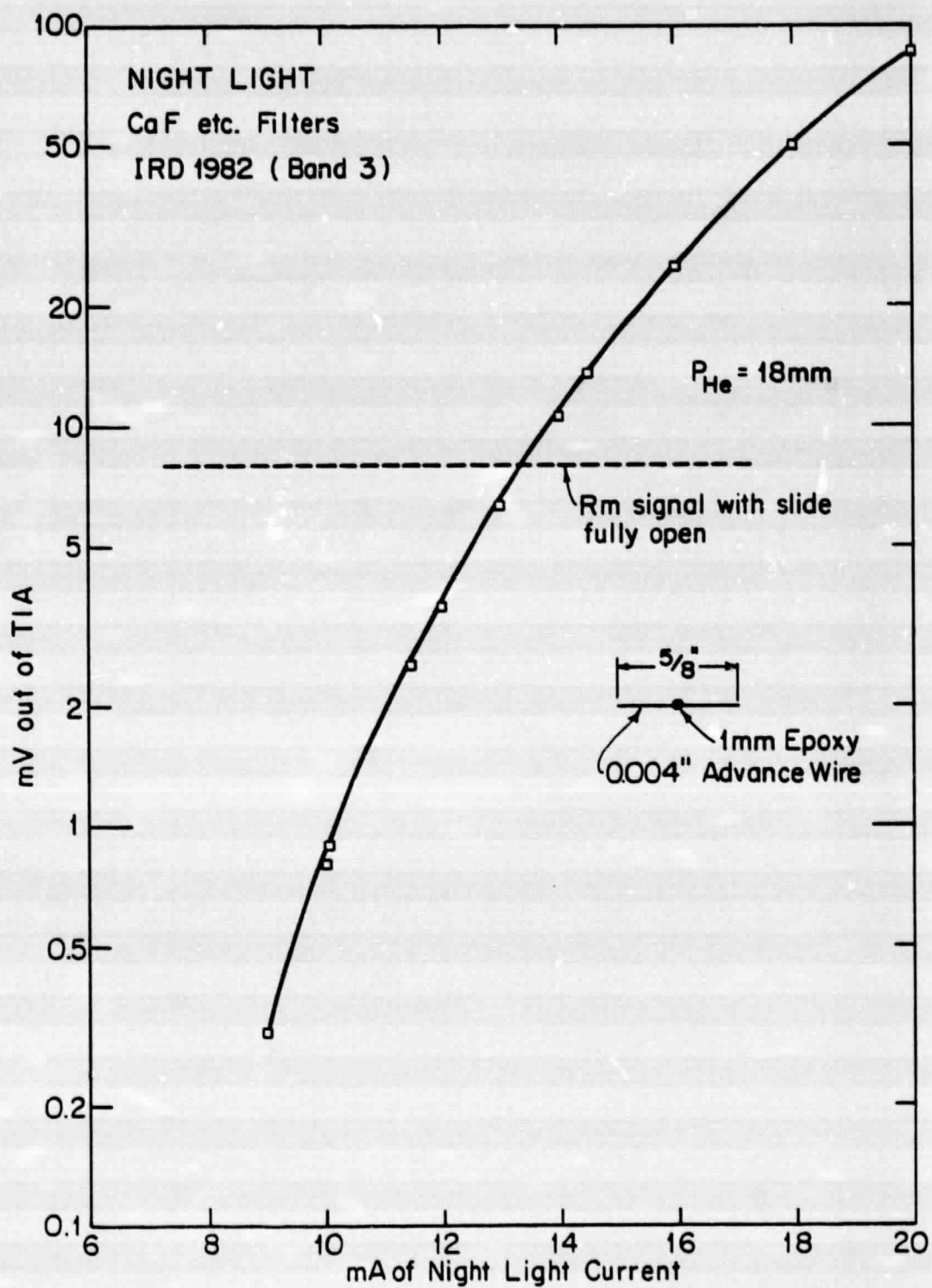
2 mV x 1 sec



P (night light)

$$= 1.5 \times 10^{-12} \text{ W}$$





ROCKWELL DETECTOR
IRD 1760

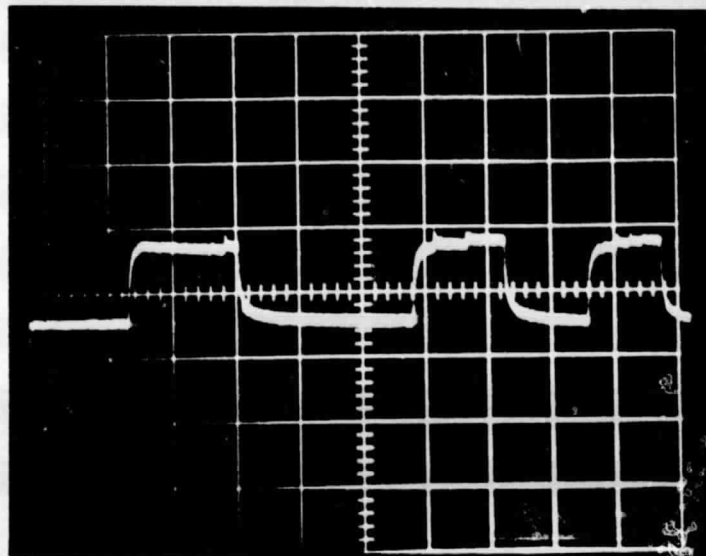
Cornell Cavity
Ge:Ga Xtal #4
Slice 51
 $\rho = 15.1 \Omega \text{ cm}$
Ion implanted contacts
0.040 x 0.060 x 0.060 in³

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OF POOR QUALITY

$$V_B = -0.1 \text{ V}$$

Optical System I

$$P = 3.37 \times 10^{-13} \text{ W}$$



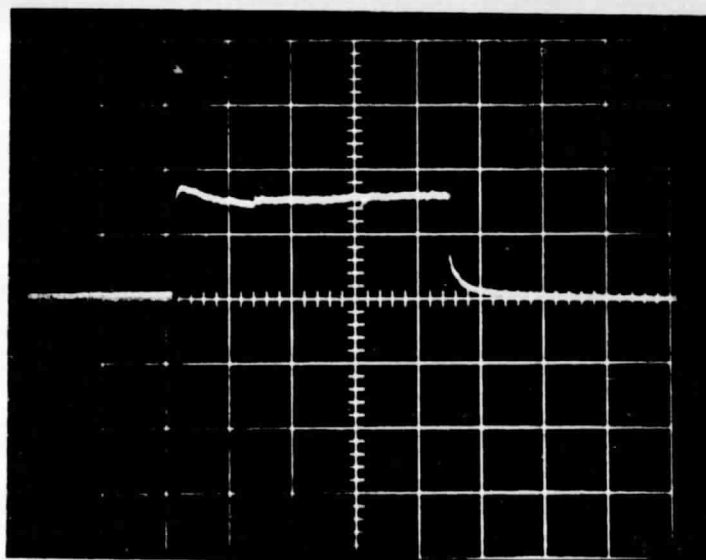
$$R_L \sim 4 \times 10^{10} \Omega$$

---Open

---Closed

ORIGINAL PAGE IN
OF POOR QUALITY

20 mV x 0.5 sec

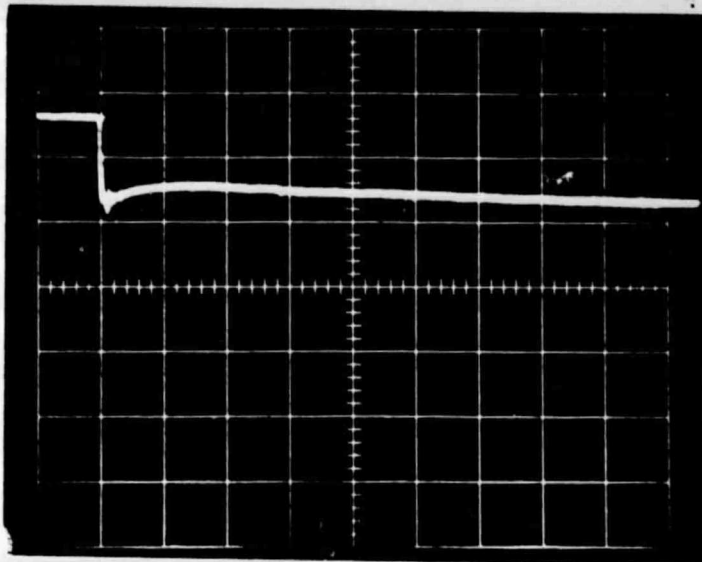


Note delayed jump like IRD 1981

Berkeley Detector #2

in Berkeley cavity

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--Closed

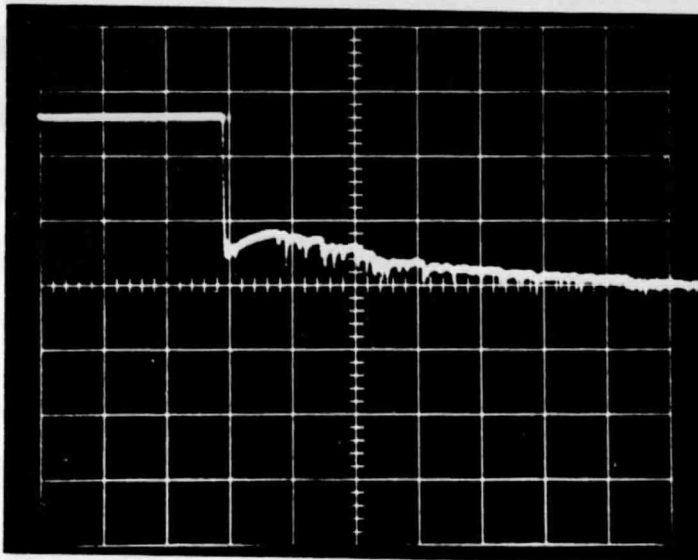
--Open

$$V_B = 0.1$$

$$R_L \sim 4 \times 10^{10} \Omega$$

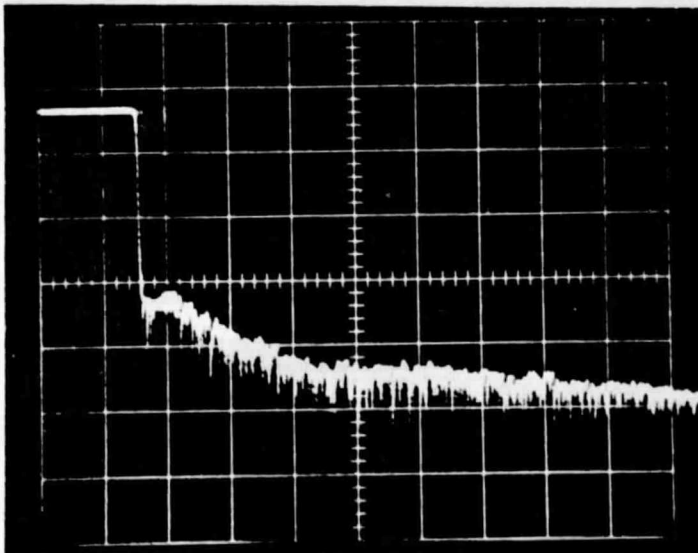
50 mV x 0.5 sec

ORIGINAL PAGE IS
OF POOR QUALITY



$$V_B = 0.2$$

$$P = 3.37 \times 10^{-13} \text{ w}$$



$$V_B = 0.3$$

Eagle-Picher Ge:Ga
IRD 1679 and 1680

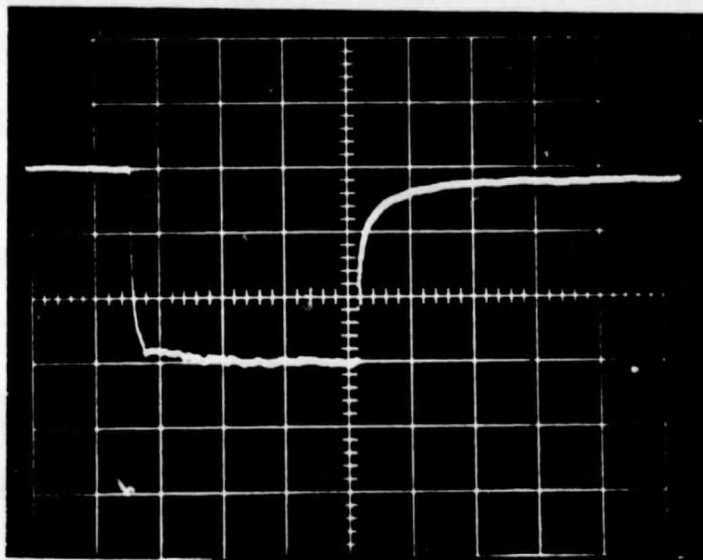
$\rho = 19.9 \, \Omega \text{ cm}$

Plated Contacts

0.047 x 0.060 x 0.060 in³

$$V_B = 0.150$$

$$P = 3.37 \times 10^{-13} \text{ W}$$

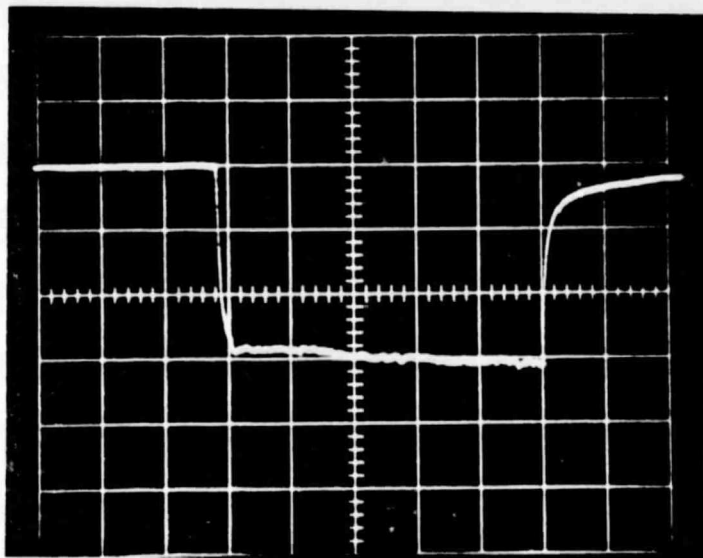


$$R_L \sim 4 \times 10^{10} \Omega$$

--Closed

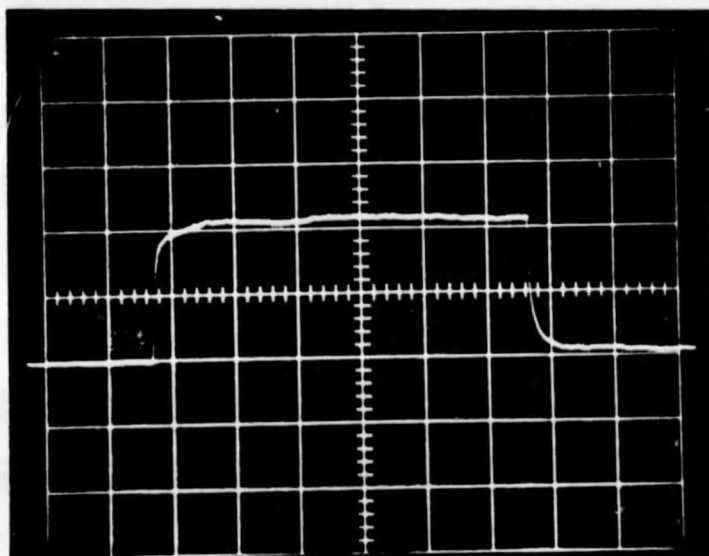
--Open

50 mV x 0.5 sec



$$V_B = - .175 \text{ V}$$

$$P = 3.37 \times 10^{-13} \text{ W}$$



$$R_L \sim 4 \times 10^{10} \Omega$$

50 mV x 0.5 sec

